Augmented Reality Applied to Geometry Education

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***Abstract*—Educational media for students to understand 3D geometry is currently conventional, schools and teaching staff find it difficult to get teaching aids as educational media tools to build 3D space. In terms of cognitive aspects, students also find it difficult to understand objects that build 3D space, because without teaching aids they are only able to imagine or imagine themselves building 3D space objects. Augmented reality (AR) is a good medium for deep collaborative simulation. This AR modeling uses marker based where the marker is incorporated in 2D geometry. In this study, we design and build applications of interactive education models on cubes, tubes, conical geometry objects as a means of learning elementary school mathematics. It is expected that this application can be a tool for mathematics teachers in delivering 3D space building material. The results obtained are 3D geometry modeling successfully read the marker and if the 3D AR model is clicked then a formula will appear from each geometry.**

Keywords—augmented reality, geometry, interactive educational model application

I. INTRODUCTION

We realize together that mathematics is one of the subjects that children do not like. This obstacle is very much realized by the teacher, however there are still many teachers who have not maximally sought efforts so that such conditions can be reduced or even turned into interesting learning [1]. In this paper, one of the basic level mathematics education materials will be discussed, namely the concept of Building 3-Dimensional Geometry Space.

Children in learning mathematical concepts through three stages, namely enactive, iconic, and symbolic. Enactive stage is the stage of learning by manipulating objects or concrete objects, the iconic stage is the stage of learning using images, and the symbolic stage is the stage of learning mathematics through symbol manipulation or symbols. Learning mathematics is the process of building or constructing concepts and principles, not just teaching that seems passive and static, but learning must be active and dynamic.

This is in accordance with the constructivist view that is a view in teaching and learning, where students build their own meaning from their experiences and interactions with others. the level of thinking of elementary school children is that they are still operationally concrete, meaning that to understand a concept the child must still be given activities related to real objects or real events that are acceptable to their reason. every mathematical concept or principle can be perfectly understood only if it is first presented to students in a concrete form. So it can be understood that how important it is to manipulate objects in mathematics learning.

To meet these demands in line with the development of science and technology, especially in the field of education, the use of instructional media becomes increasingly diverse and interactive, one of which is emerging today is to utilize AR technology [2]. Therefore, the authors are interested if this can be a new breakthrough or innovation in overcoming the shortcomings of interactive learning media, especially for sub geometry and space geometry.

One of the most important goals of an environmental education is to promote social interaction among users located in the same physical space [3]. Collaboratively Some Augmented Reality users can access shared spaces filled with virtual objects, while remaining left in the real world [4]. This technique is especially strong for educational purposes when users are classified and can use natural communication methods (sayings, gestures etc.), but can also be successfully mixed with immersive AR or remote collaboration [5]. Another important psychological factor is that some users feel unsafe if their views are "locked" in virtual immersive AR allows them to "keep in control" [6], to see the real world around them. Important security issues in collaborative cellular systems (for direct use in classrooms) where AR is clearly used to give cellular users the freedom of view needed to move [7].

This is an interaction between emotion and learning [1], but how feelings like insecurity and emotion in general influence learning is a matter of ongoing research. But developers must consider the above-mentioned problems when building their ideal learning environment [8]. The AR cannot be an ideal solution for all educational application needs but that is an option to consider The technology used must always depend on the pedagogical objectives and educational needs of the application and the target audience [9].

Spatial capacities present an imperative segment of human knowledge [10]. The term spatial capacities covers five parts, spatial recognition, spatial perception, mental

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turns, spatial relations and spatial introduction [11]. The most part, the primary objective of geometry training is to enhance these spatial abilities [12]. The beneficial outcomes of geometry instruction on the change of spatial knowledge have been confirmed [6]. Spatial capacities can likewise be enhanced by expanded reality innovation [13]. Notwithstanding, almost no work has been done towards efficient advancement of AR applications for viable training purposes in this field [14].

To fill the hole of cutting edge augmented reality interfaces for arithmetic and geometry instruction we are building up a three dimensional geometry development device considered Construct3D that can be utilized in secondary school and college training [15]. Our framework utilizes Augmented Reality to give a characteristic setting to up close and personal joint effort of educators and understudies [16]. The principle favorable position of utilizing AR is that understudies really observe three dimensional articles which up to this point they needed to compute and develop with conventional (for the most part pen and paper) strategies [14]. Our postulation is that by working specifically in 3D space, complex spatial issues and spatial connections can be preferable and quicker fathomed over with customary techniques [17]. It is vital to take note of that while geometry instruction programming imparts numerous angles to traditional 3D PC helped outline (CAD) programming at a first look, its points and objectives are on a very basic level extraordinary [18].

Geometry instruction programming is not expected for creating cleaned results, yet puts an accentuation on the development procedure itself. While generally straightforward geometric natives and activities will get the job done for the target group of age 10 to 20, the UI must be both instinctive and informational as far as the gave perceptions and instruments. Business CAD programming offers a staggering assortment of complex highlights and regularly has a stage expectation to absorb information. Conversely, geometry teachers are keen on straightforward development devices that uncover the hidden procedure exhaustively. Our going with video exhibit demonstrates the model of such an AR-based geometry training device. We present the communication and menu framework taken after by an acquaintance of how with function with Construct3D in a solitary client and in addition cooperative setup. The video finishes up with an outline of the equipment in our stationary lab setup giving a testbed to future assessments.

II. METHOD

In this exploration the framework improvement strategy utilized is Multimedia Development Life Cycle (MDLC), which comprises of 6 phases of idea, plan, gathering material, get together, testing and circulation [19]. Stages of MDLC method can be seen in Fig. 1. Stages of MDLC method include:

A. Concept

The concept stage (conceptualization) is the phase to define the nuts and bolts of a media venture that will be made and created. Particularly on the reason and sort of undertaking to be made.

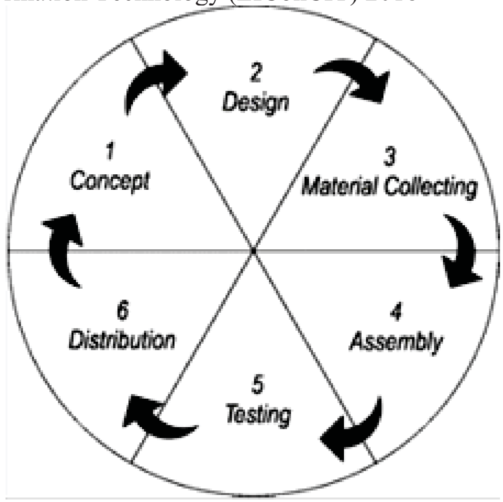

Fig. 1. Stages of MDLC Method

B. Material Collecting

Material Collecting is the phase of gathering materials that match the necessities done. With respect to material to be submitted, at that point interactive media documents, for example, sound, video, and pictures to be incorporated into the introduction of the sight and sound undertaking.

C. Assembly

The assembly stage is the phase of making all articles or interactive media materials. The materials and interactive media documents that have been gotten then gathered and orchestrated by the outline [20]. In this procedure is required master abilities with a specific end goal to get great outcomes.

D. Testing

Testing phase is done in the wake of finishing the get together stage by running for preliminary. Preliminaries are directed by applying the aftereffects of the mixed media undertaking to minor learning. It is planned that what has been made before is just before it tends to be connected in mass learning.

E. Distribution

Phase multiplication and dissemination of results to users. Multimedia needs to be packaged properly in accordance with media dissemination, whether through CD or DVD, download, or other media.

Making 3D shapes we use a blender application to form and draw geometry. The blender application itself is very familiar with 3D modeling that is open source. Basically there is no difficulty at all in forming 3D patterns in this research.

Augmented Reality Production Flowchart

Flowchart displays the stages of AR production. Flowchart can be seen in Fig. 2.

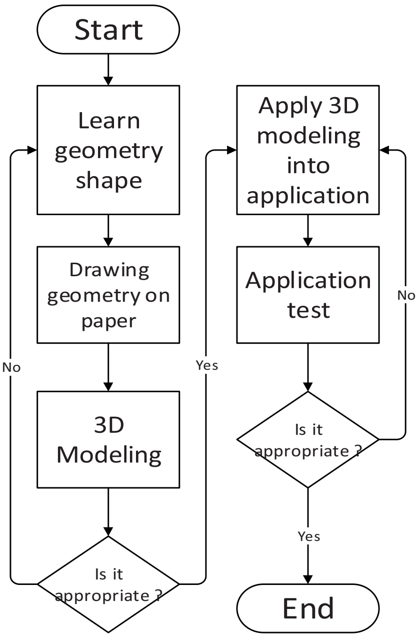

Fig. 2. AR Production Flowchart

III. Implementation

After passing the analysis and design stage on and according to the flow diagram of AR creation in the previous chapter, then at this stage will be further described the process and the result of the implementation of AR.

A. *Augmented Reality Process*

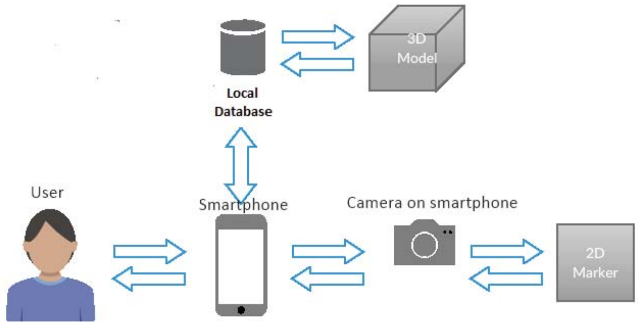

Fig. 3. AR Process

Fig. 3. shows that there is data exchange between the android device with the local database side after the camera scans the marker [21]. The phone camera scans the marker and sends the data to the android device and the android device will request information to the local database in the form of a 3-dimensional model. Then the android device will display the 3 dimensional model to the user. The components contained in Figure 3 include:

1) Users

Users are math teachers in elementary schools with geometry lessons are one important subject matter and need some media to maximize students' understanding.

2) Android device

Mobile device that has android operating system with at least version 3.0.

3) Camera

The camera is on the android device itself.

4) Local Database

Local Database contained in AR application.

5) Marker

The markers used are general 2D shapes from cubes, cones and tubes as in Fig. 4, Fig. 5, and Fig. 6. Planning 2D geometry shapes using the Corel Draw application. Markers are used as shown:

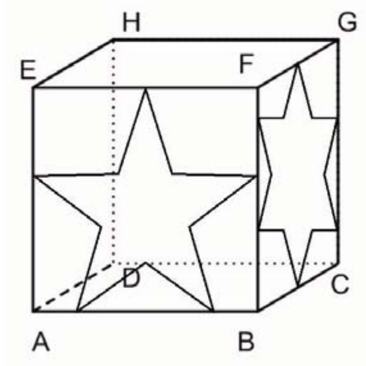

Fig. 4. Cubes

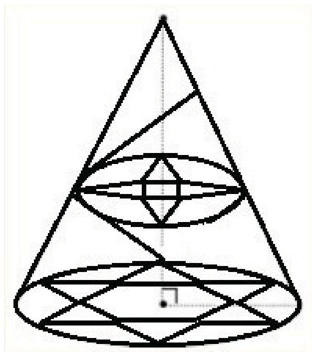

Fig. 5. Cones

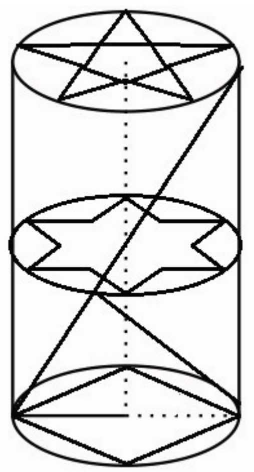

Fig. 6. Tubes

IV. Results and Discussion

The modeling that has been done, starting to be implemented in the next stage is the result of the AR scan. Existing scans appear from the markings that have been marked on the floor plan. Each scheme of determining markers is adjusted to the point where the camera will scan. Tests carried out to show the results are done on plain paper that already has their own space plan. The results obtained by this study are in accordance with the opinion which states that AR technology is one of the technologies that have not been adequately explored, especially in the field of digital fabrication.

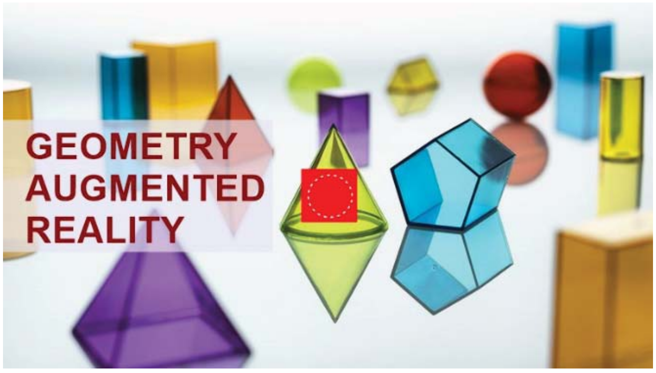

Fig. 7. Main Page AR Application

Fig. 7 there is a scan button in the middle of the main page interface. Users here can press the red scan button to enter the scan page. If you first install the application, access to the smartphone camera will automatically allow it to scan markers on objects to bring up AR from each geometry. Fig. 8 shows the display of AR in the Cube, in Fig. 9 shows the AR showing the cone, and in Figure 10 shows the AR showing the tube.

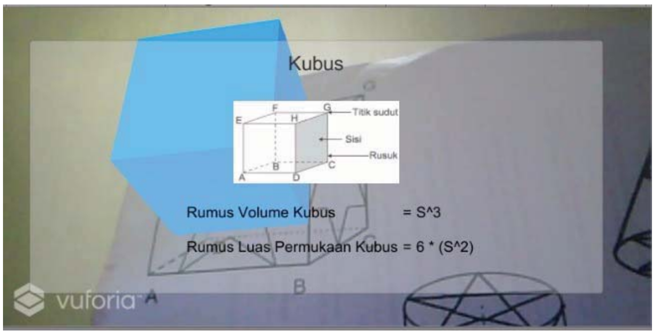

Fig. 8. Display of 3D AR for cube geometry

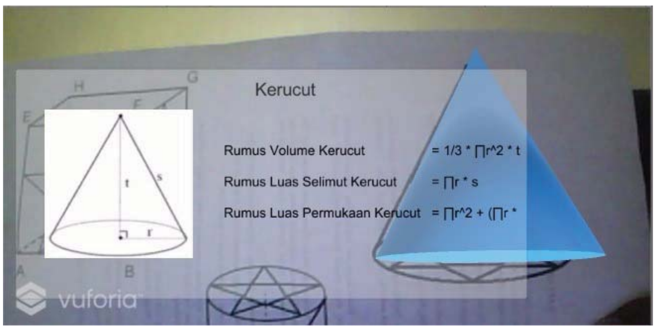

Fig. 9. Display of 3D AR for cones geometry

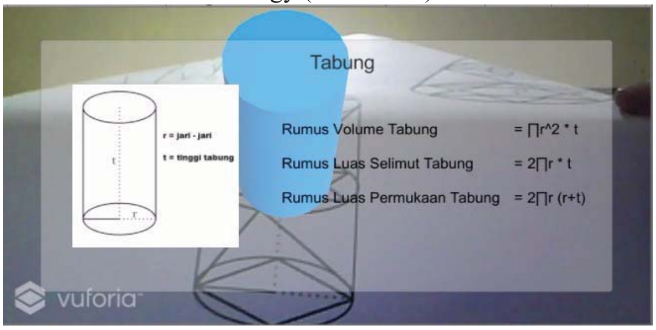

Fig. 10. Display of 3D AR for tubes geometry

The introduction of the pattern of information in this AR in Fig. 8-10 is that we can click on the screen to build space so we will get the formula information used to calculate each pattern of the space. Details of this feature make it easy to identify the use of AR for the introduction of the function patterns of each space and will be useful later.

AR testing we use light intensity testing because the camera becomes its own life in AR operations. Testing of light intensity is carried out with different lighting conditions. Here the author uses the Lux Light Meter application contained in the Google Play Store to measure light flux per unit area. For the results of testing the intensity of light can be seen in Table I.

TABLE I. TESTING LIGHT INTENSITY

Light Intensity (Lux)	Status	Detection Time (Second)
0 – 95	Failed	-
– 300	Sometimes	4
>300	Succeed	2

Light intensity test results show, on 0-95 lux, the application fails to detect markers because the lighting is too dark so the camera cannot detect markers while 95-300 lux can sometimes detect markers. The intensity of light in more than 300 lux is rated as the most appropriate level of lighting to be used in detecting markers.

Based on the evaluation results in AR applications there are some suggestions for further application development On the next application development [16] is expected so that applications can be used on other platforms such as Apple iOS. In the next application development is expected to have features to display the room information, the addition of markers and 3D models for other rooms and so the application can change the material or color of the existing peripherals.

V. CONCLUSION

The latest advances in cellular technology, cellphone cameras, GPS, and Internet access, make AR available to everyone who owns a smartphone. As a result, many educators and developers are beginning to explore the potential of AR to teach and learn in a variety of subjects and contexts. However, so far only a few studies have tried to measure the effect of AR on learning outcomes. To the best of our knowledge, the study presented here is the first field experiment on the effects of AR in studying mathematics. The empirical evidence we collected provides strong support for the proposition that AR has the potential to be an effective tool for studying formal content (mathematics).

The expected result of this AR geometry application is that it can help most teachers to use visual space visuals which are considered to improve elementary school students' understanding of mathematics subjects in 3D space building materials. Likewise, using this application is expected to make it easier for the teacher to present the material, and shorten the duration of time needed in sending the material. This 3D space model based on AR is able to create a new atmosphere that is more interactive in ordinary mathematics learning that seems boring for students.

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