

# Teaching Mathematics using Augmented Reality

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## **Abstract**

*Information technology enables us to develop innovative learning/teaching tools for mathematics education both in the classroom and out-of-school activities. This paper shows a brief potential and challenges of using Augmented Reality (AR) in mathematics education. The learners can view geometrical objects in 3-dimension having better understanding of the structures. Mobile phones or computer tablets can be used to view the 3D geometrical objects using special application software. Autodesk Maya software is used to draw geometrical objects and some AR viewing software can be used to view the objects in 3D. This paper will describe how to develop a simple AR system for the improvement of abilities of learning mathematics. Sample AR materials used for mathematics education at high school as well as university level will also be discussed.*

## **1. Introduction**

Augmented Reality in education is relative new but developing rapidly. Sometimes mathematics, especially geometry, in the classroom is difficult to understand because the students have to imagine in a three-dimension way. Virtual Reality (VR) can be used to arouse curiosity and raise motivation of students to enhance the learning process with a high potential.

Azuma [1] gave a good definition of Augmented Reality (AR). AR is a variation of VR. AR allows the users to see the real world with virtual objects composited with the real world. The users can also see geometrical virtual objects like a cube or a cone in 3D superimposed with the pictures of a cube or a cone in 2 dimensions in a textbook. This will help the students to visualize for better understanding.

## **2. Related Work**

For better understanding of mathematical models, Virtual Reality (VR) can be used to raise interest of the students as suggested by several authors [9, 11, 12]. Information technology enables us to develop a new approach for mathematics education both in the classroom and out-of-school activities. The important purpose of an educational environment is to introduce social interactions among users in the same physical area [12]. Construction of 3D objects combines four research areas: geometry, pedagogy psychology and augmented reality. There are several researchers developed Augmented Reality from Virtual Reality [2, 3, 4, 13, 6 and many others]. The educational dynamic geometry applications such as Geometer's Sketchpad [5], Cindarella [10], Euklid [8] and Cabri Geometry [7] support two- dimensional geometry only. Augmented Reality is a rapidly developed with connections of computer graphics and user interface research.

### 3. Applications

Mobile phones and computer tablets become common tools in daily life. The people always use mobile phones as calculators. Information technology can enable us to develop applications on mobile phones for mathematics education purposes. In order to create 3D objects for mathematics education approaches, we need software for making 3D geometrical models and for scanning or viewing the objects.

There are several software applications using for creating 3D objects in the market. These applications can run on mobile phones or on computers. In this paper I used software Autodesk Maya to create 3D geometrical objects for AR applications. This software can be purchased from personal or commercial uses from website: [www.autodesk.com](http://www.autodesk.com). There is also a student version for educational purposes only.

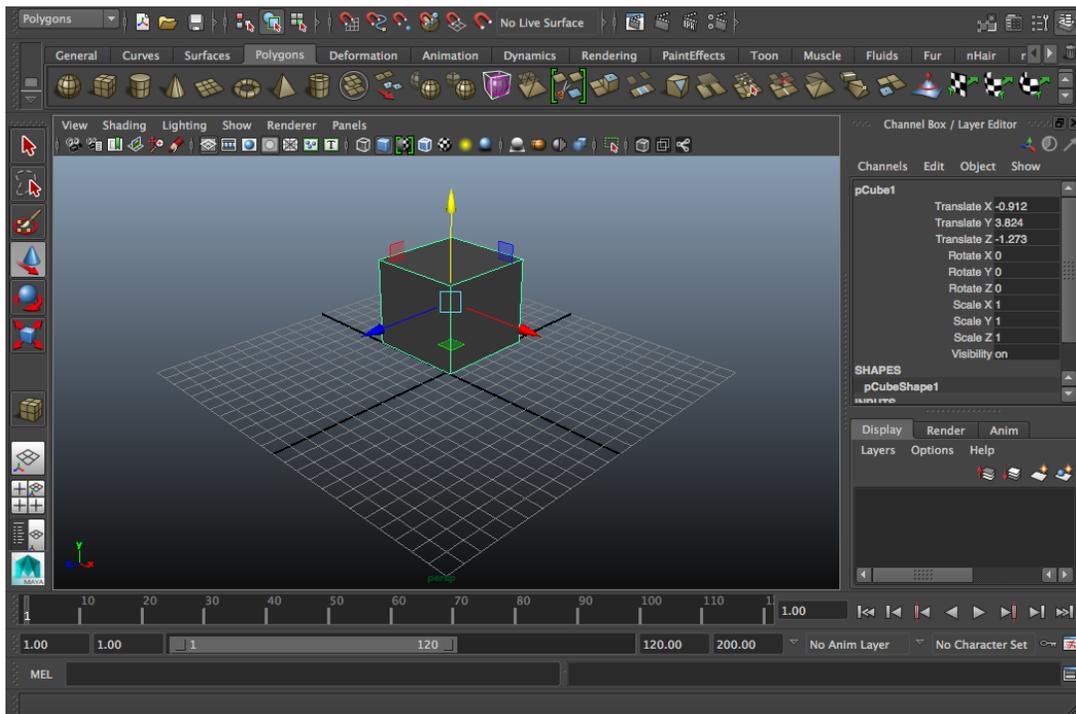


Fig.1 Working screen of Autodesk Maya for making a model of a cube.

We have to run the programme Autodesk Maya on a computer to create a model. A type of model can be chosen by clicking a button on the model menu on the top left of the screen. The size and position can be adjusted by dragging a mouse to create the chosen model. The Fig. 1 shows the cube model created by Autodesk Maya. After the model is created, it must be saved using an export command to store the model in a working folder. The model must be saved in the file type

DAE. In this case, the model is saved under the name CUBE.DAE. This model (a cube) will be used to display in a 3D floating on a background in a real world.

In order to construct an AR of the model we created from Autodesk Maya, we need another software to link the model to the background or tracker. The software for Augment Reality can be purchased from <http://www.augmentedev.com/>. A student version can also be obtained for educational purposes only by contacting the software provider.

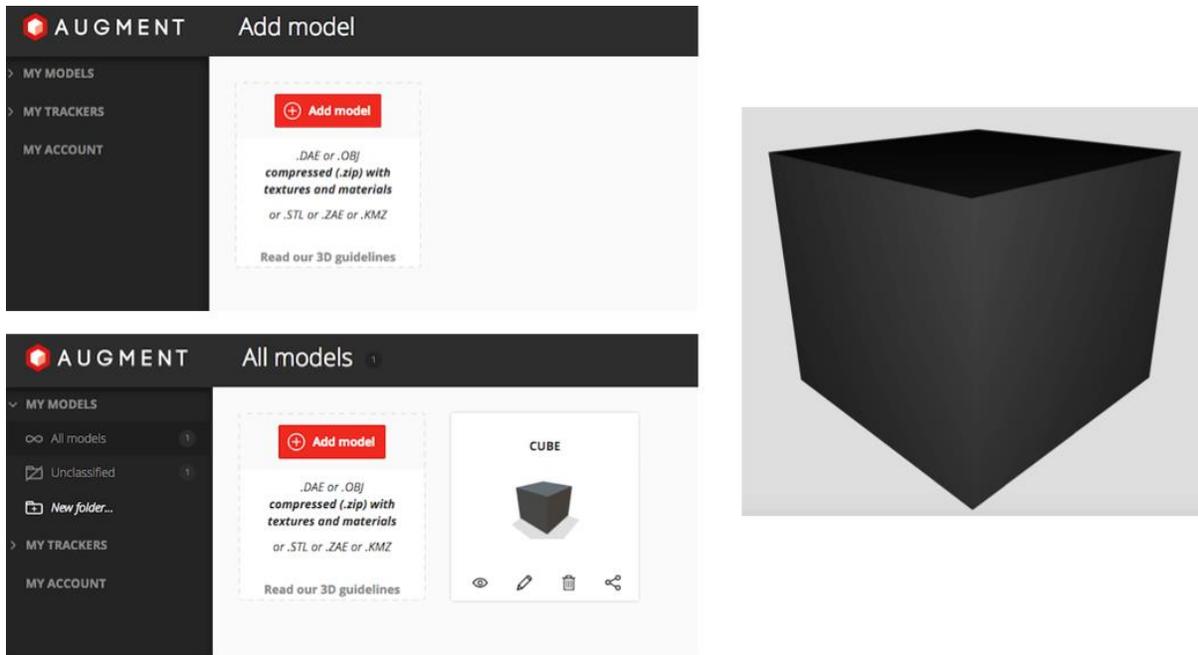


Fig.2 Working screen of Augment for making an AR of a cube model.

When we go to Augment website, we can see the working screen as shown in Fig. 2. The cube model we saved in the working folder of Autodesk Maya has to be added to the AR folder by clicking the button ADD MODEL on the screen. After upload the cube model to Augment folder, a picture of a cube will appear on the screen.

In order to view 3D cube model of AR using a mobile phone or a computer tablet, we need a background picture to be scanned. The background is called tracker.

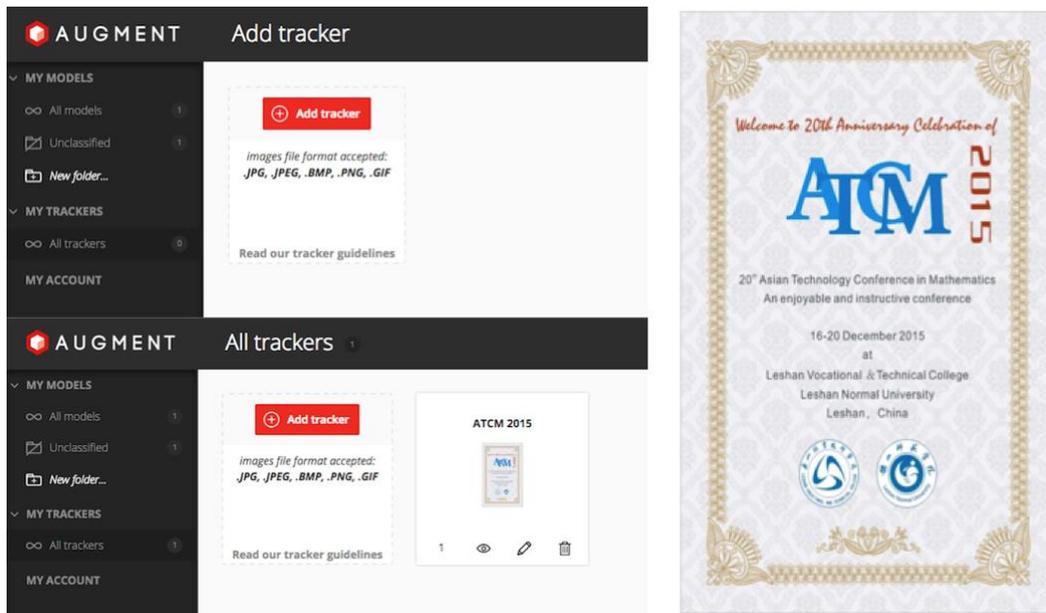


Fig. 3 A working screen of Augment for uploading a tracker to AR folder. In this case an ATCM 2015 poster is used as a tracker for AR of a cube model.

We have to prepare a tracker so that it will be used to scan and link with the model that we have in the model folder. An ATCM 2015 poster is used as a tracker for AR of a cube model. In order to upload a tracker photo, we have to click an ADD TRACKER button on the Augment screen. The ATCM tracker is uploaded in to the tracker folder as shown in Fig. 3.

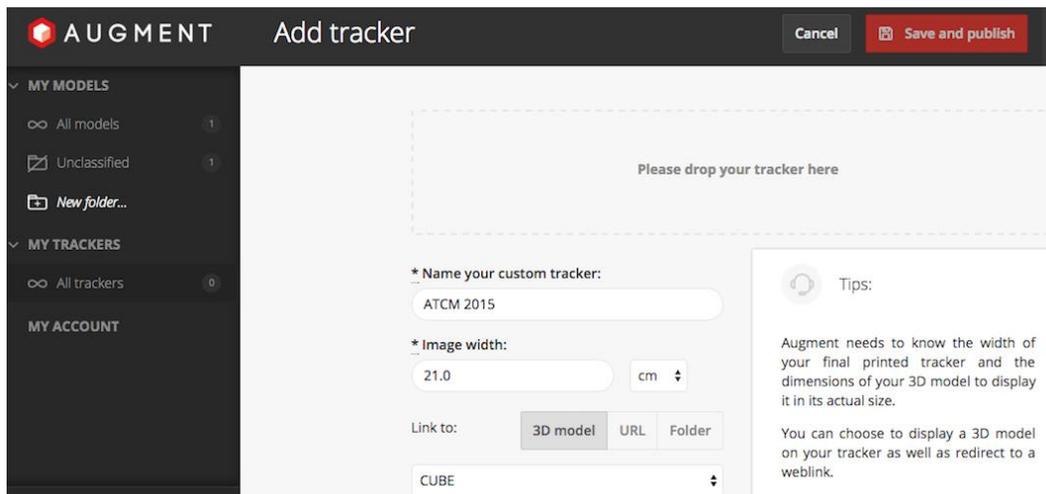


Fig. 4 Press Save and publish to form the link between the model and the tracker.

The last step to view AR 3D image of the model is to download a special software application for scanning the tracker. In this paper I used application “AUGMENT” for iPhone. When running the application AUGMENT, the menu of the functions will appear as shown in Fig. 5. Press scan button to scan the ATCM 2015 tracker on the left hand side of the Fig. 5.



Fig. 5 Using AUGMENT application to scan the ATCM tracker to view 3D model.



Fig. 6 A cube model viewing from different angles.

After scanning a tracker, a cube model will appear in front of the ATCM tracker when using a mobile phone to scan. 3D images of a cube model can be seen from different positions like a real object floating in the air with tracker background.

#### 4. Using Augmented Reality in the Classroom

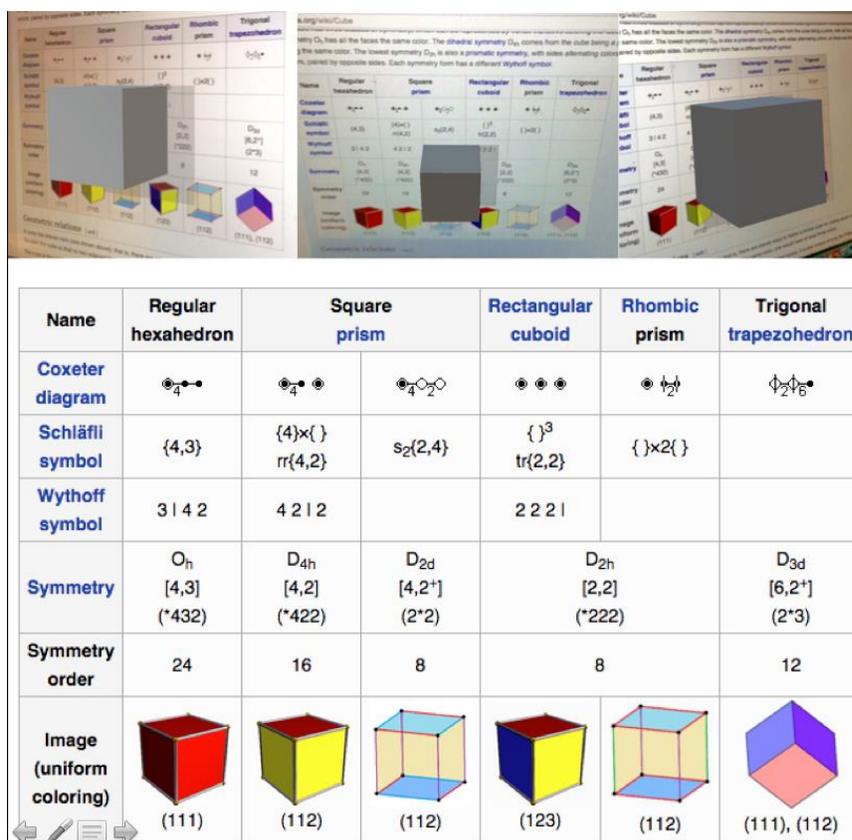


Fig. 6 Different views of a cube model using a page of textbook as a tracker related to the content in the book.

With the help of AR the teachers can raise interest and motivation of students to enhance the learning process with a high potential for better understanding. It will be more interesting if the teachers can create various AR geometrical models using some pages of the textbook or worksheets as trackers related to the contents being studied. The students can use their own mobile phones or computer tablets to view 3D objects they are studying coming out from the pages and the Virtual objects can be seen from different angles in a 3-dimensional way. The sample of this idea is shown in the Fig. 6.

## 5. Conclusion

Author conducted several mathematics workshops for teachers and camps for students and was looking for new ways to review math terms for better understanding. Author tried the way using QR codes as well as GIF animator. These ways could make more fun in the classrooms. Augmented Reality (AR) is another way that author tried to make classroom more interesting and fun. This could raise interest and motivation of the learners. Using geometrical pictures in the textbook as trackers to create AR objects, the learners paid more attention to the classroom and they studied more from textbook. Author asked students to create their own AR objects related to the topics they are studying. Some of the students used their own AR objects linking with QR codes as well as GIF animator for their work. The learners shared their AR works among groups. This shows a very strong impact in improving learning environment of mathematics classroom or even self-study anywhere.

## References

- [1] Azuma, R. A Survey of Augmented Reality. PRESENCE: Teleoperators and Virtual Environments, Vol. 6, No. 4, pp. 355-385, 1997.
- [2] Bell JT, and Fogler HS. The Investigation and Application of Virtual Reality as an Educational Tool. In Proceedings of the American Society for Engineering Education 1995 Annual Conference, Session number 2513, Anaheim, CA, 1995.
- [3] Bricken M, and Byrne C. Summer Students in Virtual Reality: A Pilot Study on Educational Applications of VR Technology. In A. Wexelblat (Ed.) Virtual Reality, Applications and Explorations. Cambridge, MA: Academic Press Professional, 1993.
- [4] Byrne CM. Water on Tap: The Use of Virtual Reality as an Educational Tool. Unpublished Ph.D. thesis, University of Washington, College of Engineering, 1996.
- [5] JackiwN.TheGeometer'sSketchpadVersion3.KeyCurriculumPress,Berkeley,1995.
- [6] Kaufmann H, Schmalstieg D, and Wagner M. Construct3D: A Virtual Reality Application for Mathematics and Geometry Education. Education and Information Technologies 5:4, pp. 263-276, 2000.
- [7] Laborde JM, and Bellemain F. Cabri-Geometry II. Texas Instruments. Copyright Texas Instruments and Université Joseph Fourier, CNRS, 1998. URL: <http://www-cabri.imag.fr/index-e.html>
- [8] MechlingR.EuklidDynageo,2000.URL:<http://www.dynageo.com>

- [9] Pantelidis, V. S. Reasons to Use Virtual Reality in Education, *VR in the Schools* 1(1), 1995. URL: <http://www.soe.ecu.edu/vr/reas.html> (Revised 2000)
- [10] Richter-Gebert J, and Kortenkamp UH. *The Interactive Geometry Software Cinderella: Version 1.2 (Interactive Geometry on Computers)*, 1999. URL: <http://www.cinderella.de/>
- [11] Roussos, M., Johnson, A., Moher, T., Leigh, J., Vasilakis, C., and Barnes, C. *Learning and Building Together in an Immersive Virtual World*. *PRESENCE* 8(3), pp. 247-263, MIT Press, June 1999.
- [12] Winn, W. *A Conceptual Basis for Educational Applications of Virtual Reality*, Technical Report TR 93-9: <http://www.hitl.washington.edu/publications/r-93-9/>, 1993.
- [13] Winn W. *The Impact of Three-Dimensional Immersive Virtual Environments on Modern Pedagogy*. HITL Technical Report R-97-15. Discussion paper for NSF Workshop. Human Interface Technology Laboratory, University of Washington, 1997.