EduRe Journal
International Journal on Advances in Education Research ISSN: 2340-2504

Augmented Reality tools for teaching and learning

Figueiredo, Mauro[1*], Gomes, José[2], Gomes, Cristina[2], Lopes, João[3]

[1]*Centro de Investigação Marinha e Ambiental, Centro de Investigação em Artes e Comunicação, Instituto Superior de Engenharia, Universidade do Algarve, Portugal*
* Campus da Penha, 8005-139 Faro, mfiguei@ualg.pt, +351289800100
[2]*Centro de Investigação em Artes e Comunicação, Universidade Aberta, Universidade do Algarve*
[3] *Centro de Investigação Marinha e Ambiental, Instituto Superior de Engenharia, Universidade do Algarve, Portugal*

Received: 2013-12-06; Accepted: 2014-03-05

Abstract
Smartphones and tablets are becoming less expensive and many students already bring them to classes. The increased availability of smartphones and tablets with Internet connectivity and increasing power computing makes possible the use of augmented reality (AR) applications in these mobile devices. This makes it possible for a teacher to develop educational activities that can take advantage of the augmented reality technologies for improving learning activities. The use of information technology made many changes in the way of teaching and learning. We believe that the use of augmented reality will change significantly the teaching activities by enabling the addition of supplementary information that is seen on a mobile device. In this paper, we present several educational activities created using free augmented reality tools that do not require programming knowledge to be used by any teacher. We cover the marker and marker less based augmented reality technologies to show how we can create learning activities to visualize augmented information like animations and 3D objects that help students understand the educational content. There are currently many augmented reality applications. We looked to the most popular augmented-reality eco-systems. Our purpose was to find AR systems that can be used in daily learning activities. For this reason, they must be user friendly, since they are going to be used by teachers that in general do not have programming knowledge. Additionally, we were interested in using augmented reality applications that are open source or free.

Keywords
Augmented reality; m-learning; e-learning.

1. Introduction

Smartphones and tablets nowadays have processing capabilities that makes it possible the use of augmented reality (AR) applications in these mobile devices. In the near future, eventually everyone has a smartphone or a tablet that is capable of displaying augmented information (Nielsen 2012). This makes it possible for a teacher to develop educational activities that can take advantage of the augmented reality technologies for improving learning activities. We believe that the use of augmented reality will change significantly the teaching activities by enabling the addition of supplementary information that is seen on a mobile device.

In this paper, we present several educational activities created using augmented reality tools that do not require programming knowledge to be used by any teacher. We looked to the most popular augmented-reality eco-systems and chose those that can be used in daily learning activities. Such augmented reality systems should be user friendly, since they are going to be used by teachers that in general do not have programming knowledge. Additionally, we were interested in using augmented reality applications that are open source or free for educational projects.

This paper describes educational activities using several types of augmented reality applications. We cover the marker and marker less based augmented reality technologies to show how we can create learning activities to visualize augmented information like animations and 3D objects that help students understand the educational content.

This paper is organized as follows. Section II surveys the most common augmented reality eco-systems. Section III describes two activities based on marker less AR technology: i) one for kindergarten and ii) an augmented reality book. In section IV we present activities supported on marker based augmented reality for teaching music. It is also presented in section V a marker based example for improving the learning of orthographic views by showing the 3D model in an augmented reality application. Finally conclusions are presented in Section VI.

2. Augmented Reality

Augmented Reality applications combine virtual objects with a 3-D real environment in real time (Milgram and Kishino 1994; Azuma 1997). Virtual and real objects appear together in a real time system in a way that the user sees the real world and the virtual objects superimposed with the real objects. The user's perception of the real world is enhanced and the user interacts in a more natural way. Virtual objects can be used to display additional information about the real world that is not directly perceived.

In general, augmented reality applications fall in two categories: geo-base and computer vision based.

Geo-based applications use the mobile's GPS, accelerometer, gyroscope, and other technology to determine the location, heading, and direction of the mobile device. The user can see 3D objects that are superimposed to the world in the direction he is looking at. However, this technology has some problems. The major problem is imprecise location, which makes difficult for example the creation of photo overlays.

Computer vision based applications use image recognition capabilities to recognize images and overlay information on top of this image. These can be based on markers, such as QR (Quick Response), Microsoft tags or LLA (latitude/longitude/altitude), or marker less that recognize an image that triggers the overlay data.

There are currently many augmented reality applications and development systems for Android and iOS (iPhone Operating System) smartphones and tablets.

The most popular ones are: Wikitude, Layar, Metaio, Aurasma and Augment .

Wikitude delivers the Wikitude World Browser for free, which is an augmented reality web browser application, and the Wikitude SDK (software development kit) for developers, which is free for educational projects. However, the educational version of the wikitude SDK always displays a splash screen and the wikitude logo. The wikitude browser presents users with data about their points of interest, which can be the surroundings, nearby landmarks or target images, and overlays information on the real-time camera view of a mobile device. Augmented reality learning activities can be realized with the wikitude SDK. The wikitude SDK can be used to display a simple radar that shows radar-points related to the location based objects. It is also possible to

recognize target images and superimpose 2D or 3D information on top of them. The developer can also combines image recognition and geo-base augmented reality. However, the building of these capabilities using the wikitude SDK requires programming knowledge.

Layar has the Layar App, an augmented reality web browser, and the Layar Creator, which is a tool for creating interactive printing documents. With the Layar Creator it is very easy to make an interactive document for a teaching activity. There is no need to do any programming and, in this way, it does not require any developers with programming skills. The teacher can easily upload the trigger page to which he wants to associate augmented information. Marker less image recognition techniques are used and with the Layar Creator interface, the teacher can easily associate a video, for example. Later, with the Layar App, the student can view, on the display of his mobile device, the overlaid information associated to the page. These applications are both free. However, every trigger image published within the Layar's publishing environment is paid. For this reason, it is not affordable for developing interactive printing documents for teaching. Geo-location based augmented reality information is free of charge.

Metaio delivers the junaio, metaio Creator and a development SDK. Junaio is the metaio's free augmented reality browser and is free. The metaio Creator is an augmented reality tool to create and publish augmented reality scenarios and experiences within minutes. With the metaio Creator the teacher can connect 3-D content, videos, audio, and webpages to any form of printed medium or 3D map (object-based or environment-based). However this tool is paid. If a user wants to develop augmented reality applications for iOS or Android, the developer can use the metaio SDK. However, this development SDK is also paid.

Aurasma delivers the Aurasma App and the Aurasma Studio. The Aurasma App is available for Android and iOS and uses advanced image recognition techniques to augment the real-world with interactive content such as videos, 3D objects or animations associated to trigger images or geo-based information. The Aurasma Studio is an online platform that lets the teachers create and publish their own augmented reality information in an intuitive and user-friendly environment. It is not required any programming

knowledge and very teacher can upload trigger images that can be associated to videos, images, 3D objects or other information.

Augment is another application for Android and iOS that uses augmented reality to visualize 3D models triggered by QR codes. After registering at the augment website, the teacher can upload a 3D model that is triggered by a QR code.

3. Creating learning activity using marker less AR technologies

In this section, we introduce the augmented reality technologies that we found more appropriate to create learning activities based on an image that triggers an animation that can be used for teaching activities in a kindergarten (subsection 3.1) or for creating an Augmented Reality book (subsection 3.2).

3.1 Activities for kindergarten

In a kindergarten a childhood educator frequently reads a story to children and then makes an activity about it. In this section, it is shown a form of a puzzle (fig. 1-a) that is shown to children after the childhood educator reads to them the story of the ”Frog and Duck”. The children have to choose the appropriate character (fig. 1-b and c) to the question formulated by the childhood educator to place in the puzzle. Once they choose the right character, the trigger image (fig. 2) activates the associated animation that was generated with Microsoft Power Point.

The images presented in figures 1 and 2 were created from an original image from the story and edited using GIMP (GNU Image Manipulation Program). Although GIMP is an advanced application, it was easy to use and very useful for: i) extracting the characters with transparency from the original image and to ii) fulfill the background after removing the duck. For this purpose, we used the GIMP Foreground Select Tool and Heal Selection which are very easy to use and yet very powerful.

(a) (b) (c)

Figure 1. (a) Puzzle; (b) and (c) two of the possible characters that children have to choose.

After making the trigger image and the animation, it is time to use an augmented reality eco-system so that when using a mobile device it can recognize the trigger image and activate the animation.

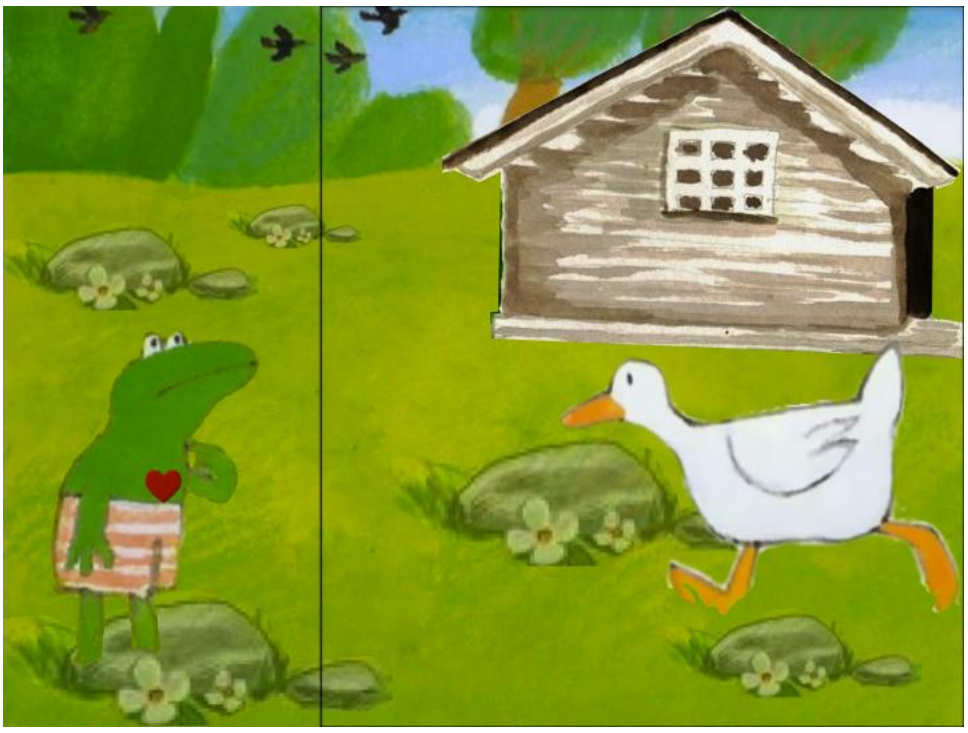


Figure 2. Trigger image that is used to start the animation.

3.2 Creating an Augmented Reality Book

The increasing availability of mobile devices in the school led to the development of the project The Sea in Music in the school year 2012-2013 at the grouping of schools of Padrão da Légua, which aimed at the integration of AR technology with the mobile-learning concept. The establishment of collaborative work between different disciplinary areas, teachers and students, was one of the main project objectives, focusing to develop an artifact with potential use in the process of teaching and learning within educational contexts. The work took the form of a book, illustrated in fig. 3, to which audiovisual elements (multimedia) were added using Augmented Reality.

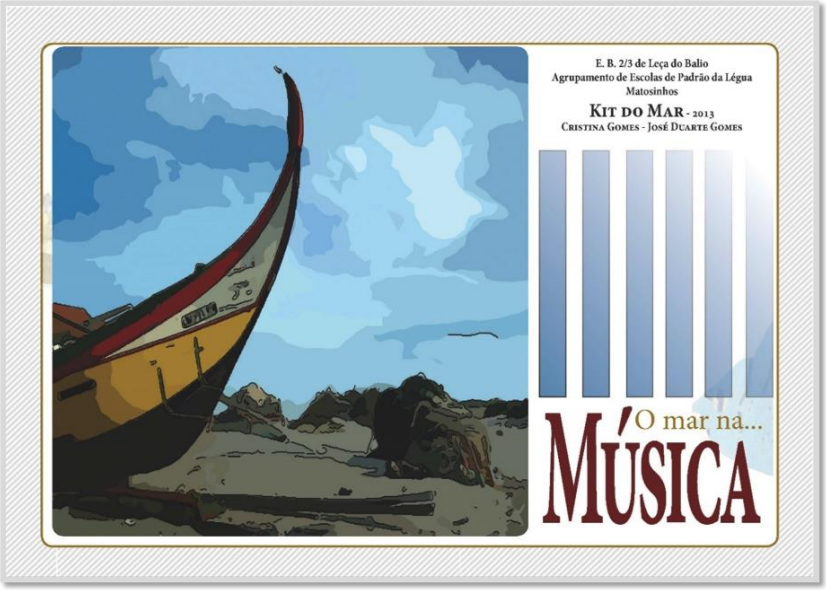


Figure 3. The Sea in Music Augmented Reality book cover.

3.2.1 Development of interdisciplinary cooperative work:

The project had the support of teachers and students in the subject areas of Music Education, Visual Education, Visual Arts, Educational Resource Center and Special Education students from the school of Leça do Balio. The unifying theme chosen was the sea. The project was presented in the IVth Contest Sea Kit, at the Pavilion of Knowledge in Lisbon on May 17th, 2013. The coordination of the project consisted in the allocation of tasks and work proposals for teachers and students, with the following contributions:

Some of the competences that the student can develop thanks to master classes would be:

- • Musical Education teachers and students focused their research efforts in finding songs that, in their lyrics or theme, included ocean related elements. That research returned a set of songs suited to play on the recorder. These songs were adapted to the recorder tessiture and complemented with orchestral accompaniment. Finally the songs were recorded onto video to support students live play, known as play-along. Information about the composers, interpreters or the song itself was gathered and present in video format (fig. 4).

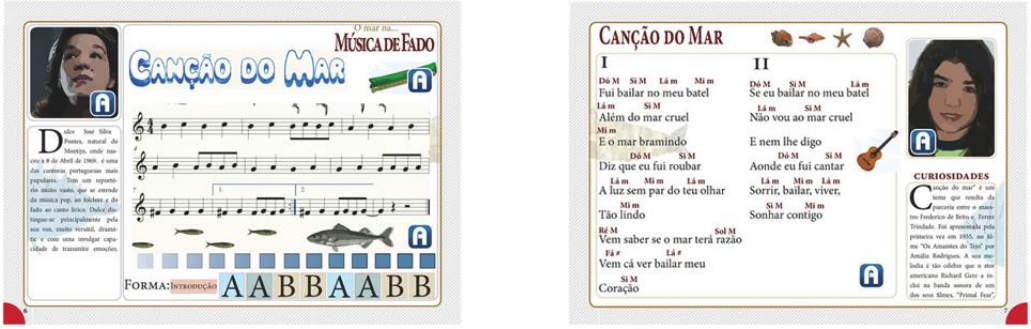


Figure 4. Musical score featuring conventional music notation, guitar chords and play-along theme curiosities.

- • Visual Education teachers and students researched the marine fauna and flora of the Portuguese coast, from which they produced a collection of drawings and art, using different techniques, from textured materials suited to the tactile experience to colored pencil or china ink contour (fig. 5).

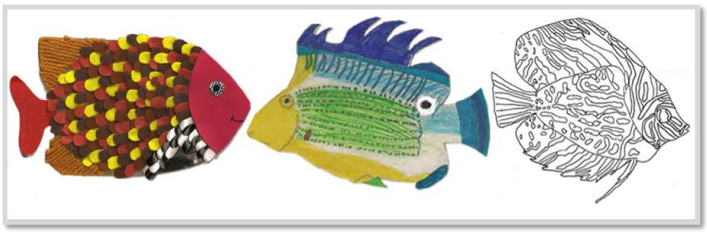


Figure 5. Student art depicting the Portuguese coast marine fauna.

- • The Visual Arts teachers and students produced two short movie sequences, animated according to the stop-motion technique. One was created using mold- able

plastic figures, the other recurring to simple sequential drawings. The movie The Little Girl and The Sea Star received a sound track fully elaborated by a special education student (fig. 6). The movie sound track involved environment sounds recollection and audio manipulation in Audacity by the student itself, using different techniques and resources. The final video file, was produced in Movie Maker according to a storyboard depicting the scenes, planes and the audio soundtrack.

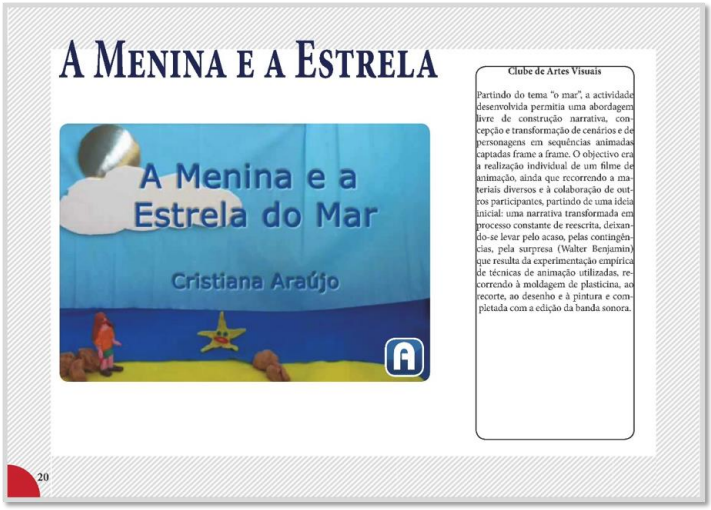


Figure 6. Short animation movie The Little Girl and the Sea Star.

- • The Educational Resources Center, contributed with a photo sequence depicting scenes from the life of Matosinhos fishermen from the past to the present day. This contribution took the form of a video with a popular sea theme related sound track.

Along the first and second period of the school year a large amount of work took shape. From these, a few were chosen according to higher quality patterns or those that meant greater effort and involvement from the students. The cooperative work established between teachers and students around a common project contributed significantly to greater involvement and motivation of all participants, extending it to the school management, the parents and the educational community.

4. Creating learning activity using marker-based AR technologies to teach music

In this section, we use marker-based augmented reality technologies to create teaching activities for improving music learning for students for the 5th grade.

Using marker-based codes for presenting additional information in a mobile device is very simple to use and straightforward. The teacher can use simple QR (Quick Response) two-dimensional codes for associating information such as text, URL or any other data. Quick response codes are much more popular than the other code formats and there are several sites where the teacher can easily create such codes.

We decided to use the Microsoft tags because for the example presented in figure 7 we want to use smaller codes that become less intrusive. Reading smaller Microsoft tags are more reliable then the equivalent QR codes.

Microsoft tags are also very easy to create, requiring only the registration at the site http://tag.microsoft.com.

The example of figure 7 uses the Microsoft tags to show the answers to the different questions. We created other augmented reality documents with music sheets and like Beauchamp and Kennewell (2010) we also noted that the students were more interactive in the classroom, improving the learning process.

5. Augmented 3D models to improve orthographic views learning

This section presents an example of using augmented reality to create an overlay with a 3D model that is used by the teacher to help students improve learning of orthographic views. Wu and Chiang (2013) shows that applying 3D animations provided more enthusiasm for the learning activity, better performance in understanding the appearances and features of objects and improve the spatial visualization capabilities.

For this purpose, the first thing the teacher needs is a 3D modeling tool.

We used SketchUp because it is simple to use, draws the orthographical views and is free. In this way, it was easy to create the 3D model that is represented in an isometric view (figure 8-a) and the corresponding front, left and top orthographic views (figure 8-b). If

the teacher wants it is also possible to add textures to the model to make it look like a real object made of wood for example. This is very easy to do in SkecthUp, by importing a photo texture and add it to the model.

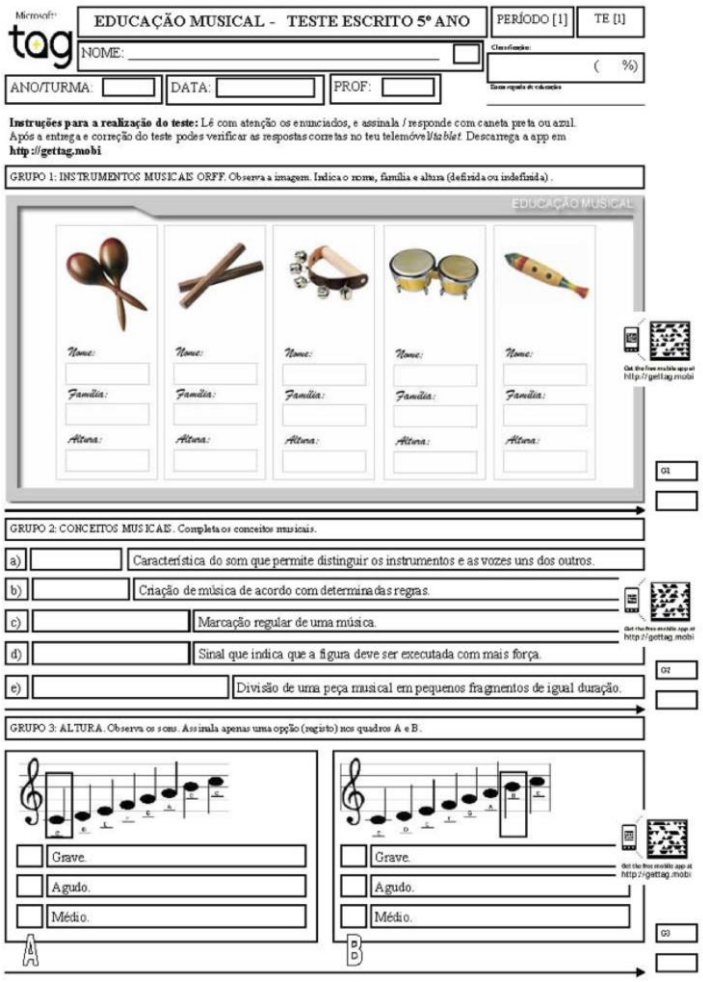
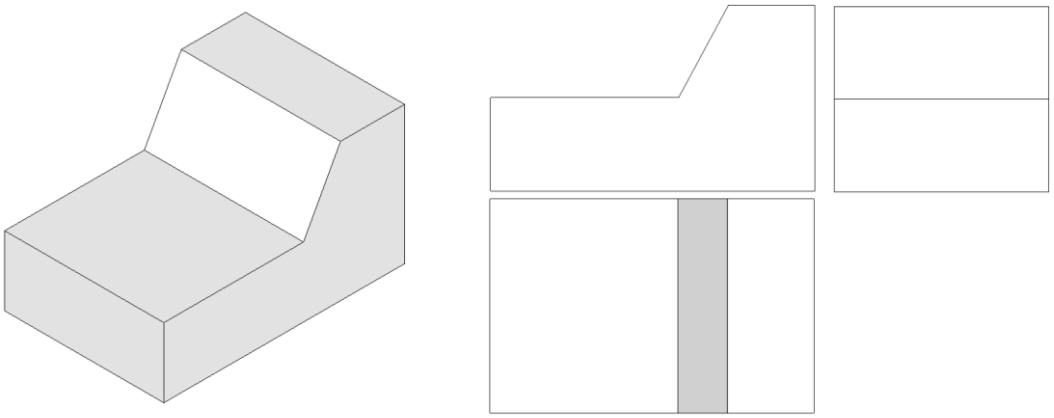


Figure 7. Music test with Microsoft tags codes.

To help students visualize and understand this 3D model, we used Augment to render the 3D model in a mobile device triggered by a QR code. To upload a 3D model on Augment, from SketchUp we can export to a Collada file (DAE). This creates a .dae file and a directory containing the textures. Next, these files are compressed together into a zip file that is uploaded on Augment and then you are ready to share your model. This example can be tried after installing the Augment application in a mobile device and print the QR code available from http://agmt.it/28855. Figure 9 presents the visualization of the 3D model that the student can use to draw the isometric projection or the orthographic views.



(a) (b)

Figure 8. (a) The isometric drawing of the model created with SketchUp; (b) the front, left and top views of the 3D model.

Figure 9. Visualization of the 3D model with the Augment application.

6. Conclusions

In this paper we presented the most popular augmented reality applications available for mobile devices.

We explored augmented reality applications that can be used by teachers and students in the classroom to improve learning.

This paper shows activities supported both on marker-less and marker based that recognizes an image that triggers the overlay data.

We presented an educational activity based on marker less images for kindergarten and an augmented reality book. These works were developed using Aurasma.

It was also presented an activity for music teaching using marker based codes. We used smaller Microsoft tags that are better recognized than the Quick Response codes.

Finally, we prefer to use the Augment application to show 3D models on top of a QR code. The example presented helps students to visualize the 3D model and draw the orthographic or the isometric views.

7. References

Azuma, R.T. (1997). A survey of augmented reality. Presence: Teleoperators and Virtual Environments 6(4), 355–385.

Beauchamp, G., Kennewell, S. (2010). Interactivity in the classroom and its impact on learning. Comput. Educ. 54(3), 759–766.

Milgram, P. and Kishino, F. (1994). "A taxonomy of mixed reality visual displays," IEICE Trans. Information Systems, vol. E77-D, no. 12, pp. 1321–1329.

Nielsen (2012). "Smartphones account for half of all mobile phones, dominate new phone purchases in the us," 2012. [Online]. Available: http://www.nielsen.com/

Wu, C.-F. and Chiang, M.-C. (2013). "Effectiveness of applying 2d static de- pictions and 3d animations to orthographic views learning in graphical course," Comput. Educ., vol. 63, pp. 28–42.