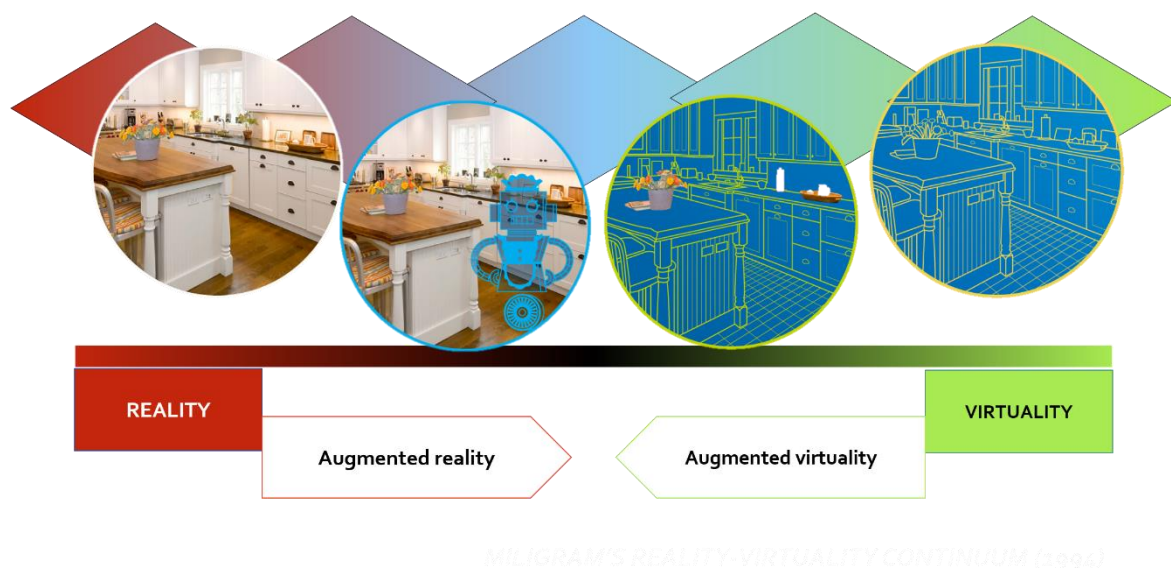


Augmented Reality for Education: Tutorial for educators

Concept of reality in field of technology can be defined by contrasting virtual and real world. This idea of describing reality and virtuality as two end points of a continuum was first presented by a group of researchers in 1995 (Milgram et al., 1995) with a simplified design that outlines the matrix of mixed reality environment. Position of AR in Figure 1 defines it as medium similar to a real environment that introduces some elements of virtuality.

Figure 1: Reality-Virtuality Continuum (based on Milgram et al., 1995: 283)



A definition of AR can be deduced from definitions of “augmented” and “reality”.

While augmenting means to make something greater or to enhance, reality stands for everything we experience around us. Therefore, Augmented Reality (AR) is a greater version of our perceived reality, a real world experience enhanced with an overlay of additional media.

The first definitions of augmented reality do not come from education studies, but have been presented in technology engineering and programming field, and as such define understanding of technical components and software principles integrated in production of augmented reality.

AR can be defined as “a situation in which a real world context is dynamically overlaid with coherent location or context sensitive virtual information” (Klopfer and Squire, 2007: 205). In that case, AR provides users with technology-mediated immersive experiences in which real and virtual worlds are blended.

Although the primary purpose of AR development was entertainment and marketing, the digitalization of the education sector has led to the expansion of AR into a specific educational technology field (Wu et al., 2013). AR today has the potential to revolutionize learning in schools more than any other technology has done in the recent past, and educational experts recognize that potential:

“Augmented learning uses electronic devices to extend learners’ interaction with and perception of their current environment to include and bring to life different times, spaces,

characters, and possibilities. It offers opportunities for transformation of learners' perspective and their learning context." (Sheehy, Ferguson, Clough, 2014: 1)

Educational interactions with augmented reality, as mentioned by Sheehy, Ferguson and Clough (2014), are offering new possibilities for updating the learner-centred approach.

In using both educational and technical definition to develop an understanding of AR, it is clear that an interdisciplinary approach is of crucial importance. Researchers from different disciplines agree on the fact that using augmented reality as a learning tool enhances students' experience and engagement (Chen et al., 2017; Bujak et al., 2012; Radu, 2014; Bacca et al., 2014). On the other hand, it has been suggested that some students can be prone to paying too much attention to virtual information and for that reason some educators believe AR is an intrusive or distracting technology (Bacca et al., 2014).

Benefits of learning with AR tools

Augmented reality learning tools, like other technology-based learning media, offer some benefits for learners and limitations in its use. Balance between benefits and limitations can justify meaningful implementation of new tools in education. From theoretical assumptions to practical testing, those benefits and limitations are researched and a body of empirical evidence is growing. Bujak et al. (2012) have collected current research findings and created a framework for learning with AR tools that I use as a basis for my work.

Physical dimension

When a student uses computer-technology to access educational content, they must have knowledge and skills of interacting with a computer (using a mouse, accessing menus, files, imputing data using keyboard, recognizing letters on keyboard). Bujak et al. (2012) identifies this as an additional learning cost imposed on a student, which leaves less cognitive working memory for learning content. The same authors recognize AR technology as more appropriate than traditional desktop computers because it uses more natural interface which can reduce extraneous cognitive load. Another study (Tang et al., 2003) has found that students' mental effort is reduced when AR technology is utilized, compared to computer-based environment.

In learning context, physical actions in learning are beneficial for later information recall (Glenberg, Brown and Levin, 2007). Physical actions in learning process are usually facilitated by using manipulatives, especially in primary school. Bujak et al. (2012) divides manipulatives in three categories:

- **Physical manipulatives:** useful to prompt a physical action needed for learners to develop association and learn, but limited to display one concept without instructional guidance
- **Virtual manipulatives:** easily paired with pedagogical aspect of a manipulative, but lacks natural physical manipulation of an object in real world
- **AR manipulatives:** combine physical and virtual manipulation into physical experience with added virtual information or instructional guidance

Physical limitation in utilization of manipulatives can be present in settings that include young learners (Bujak et al., 2012). Their fine motor skills and coordination is developing and might not be in line with requirements of advanced AR software. Hornecker and Dunser (2009) warned that

children might not have sufficient hand-eye coordination to work with mirrored systems or to interact with two objects at once. Di Serio, Ibáñez and Kloos (2013) have identified another possible obstacle in AR utilization in education – if the students are not holding the tablet stable enough over the real image (maintaining superimposed digital content stable), the augmented content tends to glitch, making it difficult to be perceived or read.

Cognitive dimension

In primary education, children are sometimes required to understand abstract concepts (such as mathematic numeric operations) and physical representations are often used to facilitate associations and learning (Bujak et al., 2012). Other studies have confirmed that associations and learning are improved when related information is presented spatially close to represent relation (Sweller, 2010; Ginns, 2006).

Spatial and temporal contiguity is presented as a benefit in majority of studies using AR technology in various educational subjects. First example is connecting the content with the learner's active workspace, which has been shown to increase student's learning in experiment done by Kester, Kirschner and van Merriënboer (2005). In lesson covering electrical circuits, students were reported to learn better when diagram and properties of circuits were shown in one display rather than in two separate displays (Kester, Kirschner and van Merriënboer, 2005). Same principle can be applied to sequential instructions – Tang et al., (2003) reported benefits for students performing a multi-step task when instructions are integrated with task materials. For example, Pathomaree and Charoenseang (2005) report that students were faster and more successful in constructing lego-structures because of AR feature that displays specific information at the appropriate time.

More AR systems are being developed to utilize a specific visualization feature – observation and manipulation of learning content that is difficult to access with traditional tools (Bujak et al., 2012). For example, Nischelwitzer et al. (2007) have developed a system that allows students to examine and assemble virtually presented internal organs while learning about human body. Such systems enable spatial visualization with less material preparation and more individual control over content. A similar system was developed for simulating plant growth and report on the practical benefits of manipulating the amount of water and light in the environment. A process which would be time-consuming if real plants were used (Theng et al. 2007).

Contextual dimension

Collaboration is facilitating deeper learning because of multiple simultaneous interactions, students engage with content and other learners' perspectives at the same time (Bujak et al., 2012).

Collaborative work with computer-based systems is difficult because students need to shift gaze and attention between computer screen and peers constantly (Sheldon and Hedley, 2004). Computer-based systems might not offer the individual control over virtual content in collaboration, but Bilinghurst et al. (2001) highlights features of immersive virtual-reality for collaboration around digital content. On the other hand, virtual environments don't allow students to interact in non-verbal cues (Bilinghurst et al., 2001). Features of augmented reality allow students to use the best from two mentioned systems, students can engage with digital content and each other in the same space (Sheehy, Ferguson, Clough, 2014). Bujak et al. (2012) emphasizes the advantage of collaboration around same digital content that can be observed in comparison to real physical objects, simultaneously using verbal and non-verbal interactions within the group. AR technology allows each student to have individual perspective and control over content, which can facilitate higher-level discussions around investigated material (Evans et al., 2011)

Social context emphasizes accessibility for everyone, including low-income groups. Bujak et al. (2012) states that AR manipulatives that are designed as cards or graphics activated with simple camera (tablet, smartphone or web-camera) might be accessible to more students. With popularity

and availability of smartphones, they expect more students will use AR tools for learning outside the classroom, at home.


Augmented reality tools can enhance learning due to features that combine personal relevance of students' physical environment and the personalization of the virtual content, which results in students that describe experience as magical (Bilinghurst et al., 2001). AR systems, unlike immersive virtual environments, do not separate students from the reality, but transform and enhance it with digital elements. These interactive features are reported to spark curiosity (Di Serio, Ibáñez and Kloos, 2013) and enhance engagement (Chen et al., 2017; Radu, 2014; Bacca et al., 2014). Bujak et al. (2012) concludes that long-term sustainability of enhanced learning experiences could change with students' emotional adjustment to new technology.

Creating digital overlays with Blippar

The suite of tools provided by Blippar for Education includes an online creation studio, educator dashboard for organization of content and access to network of users and support team. Blippar visual discovery (or image recognition) app utilizes the camera on any smartphone or tablet device to connect the visual trigger (photo, text or graphic) to interactive media content. The presented content (defined as a “blipp” on Blippar's website) is the action of instantaneously transforming anything in the real world into an interactive experience (Blippar.com, 2015). It can contain 2D or 3D graphic material, audio or video, and interactive elements such as quizzes, links, action buttons or game-like interfaces.

Setting up an account

Blippar is free to use for basic (non-commercial) purposes, which includes all designs that can be viewed only using a test code. To start, you need to create an account on the Blippar.com website.



Create your account

Firstname | Surname

Email

Password

Confirm password

After you have filled in your name, email and password, you will be asked about the purpose of your designs. If you wish to use them only for non-commercial purpose (free) select it from a drop-down menu. There are other options to choose from, full pricing can be found on Blippar website.

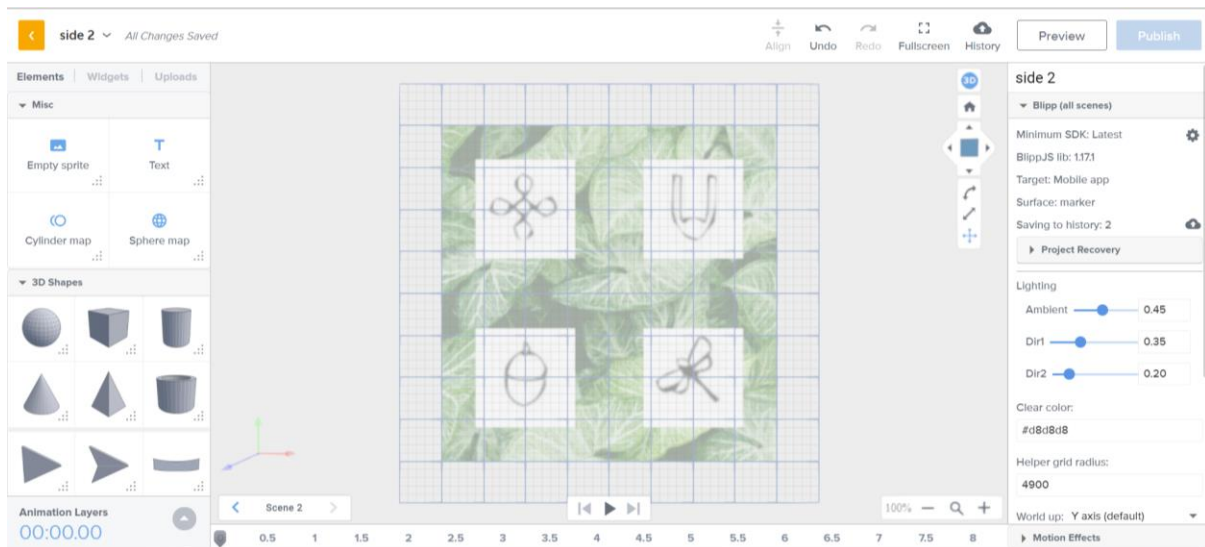
An educational license offers free access to all features to create AR content for instructional purposes and a notable feature of that license is the use of a campaign or blipp code which provides access for pupils in compliance with the Family Educational Rights and Privacy Act (Arnhem, 2016) and the General Data Protection

regulation (Blippar, 2018).

Once you have created your account, you can start designing your AR experiences, or blips.

Dashboard

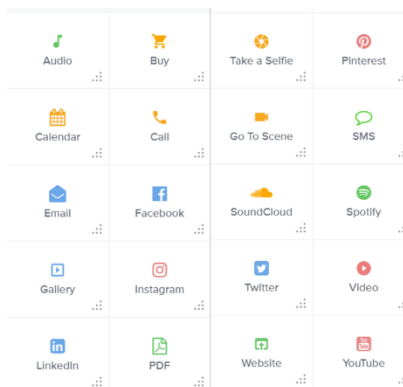
Your dashboard or workspace includes all functions and tools that will allow you to create your AR designs. As a general rule, options on the left side of the screen are for assets and objects you can add to your design, while the options on the right side offer modification of those assets.



The next sections will describe main elements of your dashboard, but if you prefer to see it in action, you can watch this video tutorial to learn about Blippar's interactive features and overlay creation steps: <https://youtu.be/x2td0r8ULaA>

On the left hand side of your dashboard, you can select pre-made elements (text box, shapes, objects), widgets (multimedia and social integration features) or upload your own assets (images, audio files, videos, 3D shapes or pdf documents).

Widgets



Widget option allows you to link to any website or use any of the following preset website widgets in your AR experience:

- Audio
- Call
- Instagram
- Pinterest
- Soundcloud
- Twitter
- Website
- Buy
- Facebook
- LinkedIn
- Go to Scene
- Spotify
- Video
- Youtube

To add a widget to the grid, simply drag-and-drop the desired widget onto the grid (position it in relation to your trigger)

Uploads

You can use any third-party design tool to create assets and upload them into Blippbuilder, just make sure they are in either JPEG, PNG, MP3, MP4 or 3D formats.

Uploading and Adding Assets to the design

- Click on the library tab found in the media panel on the left side
- Click on the box labelled "+Click to upload files" or "+ Add Media."
- Upload the image, audio or video files you wish to use in your design
- Drag and drop an asset onto the grid. The properties panel be on the right side, allowing you to add actions to your assets or modify them (as described earlier)

**Note: you can only set actions for images files. Audio files and video files will become an audio or video action by default.*

3D Models

Working with 3D objects can seem like a difficult task, but remember that various tips and pre-made elements are available for you to use (including many websites with free 3D shapes for education).

How to add 3D augmented reality to your experience

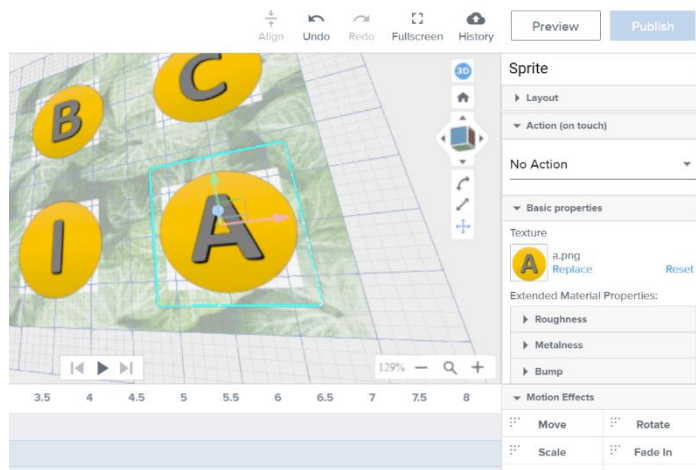
1. Upload your 3D model -- select 'Upload', choose your file, and then click 'open'.
2. If you need to, you can then use our FBX to BB3 file converter to make it the correct format for our platform.
3. You can then do a number of things with your 3D models:
 - Turn it into a button: make a link to a video, website, or social media page of your school
 - Add animation by adjusting the movement feature on the right side – for example, make a 3D boat glide across the canvas
 - Add texture: change the colour or upload your own texture file – For example, make a sphere look like planet Earth.

Check out the video below to see 3D augmented reality put into action:

https://youtu.be/InTxfib_KFM

Modification of assets and interactive functions

Depending on which element or widget is selected, the right side of the dashboard will offer modification and interactivity options specific for that element. Basic properties are present for every element and include its position in a 3-dimensional grid, its size, colours, textures and similar.



- Scale (click and drag) and rotate (blue circle) the element on the grid
- Select a colour based on the preselected colour options which are chosen automatically from the main colours of the marker or enter a HEX value to set any colour you wish
- Give your widget a name in the "Label" tab
- Choose the font and shape of the element

Each overlay element can also include different actions on-touch. Those actions can be chosen from the menu on the right side of the screen and include transitions to different scenes or audio, video, web or social media interaction. As an addition to interactive features, this platform allows for time-sensitive animations for each element added. Animations are added on the bottom part of the screen and include staggered appearing (fade in and out), movement (translation, rotation or combinations), appearance (changing opacity or size) or more complex animations (bouncing around the screen).

Scenes

Scenes are the core of many AR experiences that allow for more content than 360 degrees can fit. Like slides of a presentation, they underpin the structure and user journey of AR experiences. Scenes can link one piece of AR content to another, create games, or replicate the functionality of a simple app.

You can use scenes to create an AR quiz. Each question and each answer option will need a separate scene to be created. You can create your own quiz by following the steps below.

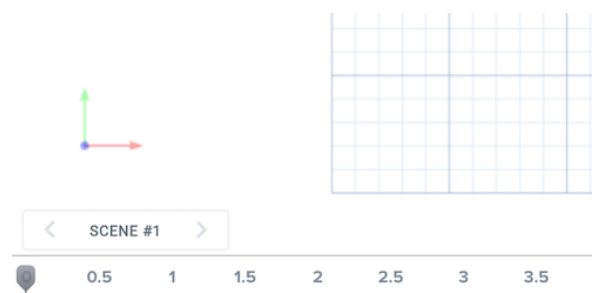
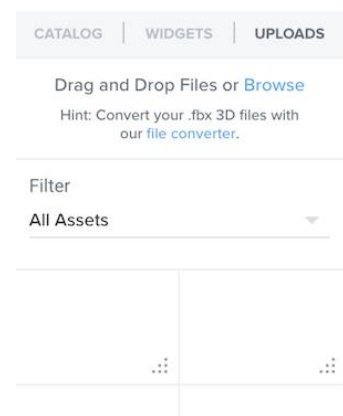
Interactive AR quiz

Step 1 Upload your assets — you'll need images for the quiz questions, answers and buttons. Select the 'Uploads' button, choose the files you want to upload and click 'open' — you can upload multiple assets at a time. Your files will appear in the assets panel on the left-hand side.

Step 2 To create your first question, drag and drop the assets you need onto the canvas.

Step 3 Resize, arrange and align each of your assets to how you want your quiz interface to look. Remember, all assets will be presented in 3D space and explored from all angles.

Step 4 Create scenes for your quiz — these are like the different slides of a presentation. Think about where you want your user to go from your first quiz scene. For example, if you have two multiple choice options, a user will either need to be linked to the 'correct answer' scene, or 'incorrect answer' scene. Click on the 'Scene' button in the bottom left hand corner to open the scene manager and add new scenes — rename them to help you organise.



Step 5 You now need to make your assets — the quiz buttons — **interactive**, to let your user link to the different scenes. Select the element (asset) for your first quiz answer, for example, the correct answer. Next, in the settings pane on the right-hand side, select 'Go to scene' from the drop-down menu. Then, select which scene you want it to link to — in this case, it's the 'correct answer' scene you created in step 4.

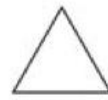
Step 6 Repeat the process until you have created each question of your quiz! The result will be a quick, fun experience that launches in augmented reality.

Hexagon puzzles

Discovery learning is important for all age groups. One of many solutions for quick difficulty differentiation, and my all-time favourite is using shapes and colours.

For this puzzle tutorial I will use hexagons, but you can easily make your puzzle more complex by using octagons, nonagons, decagons...or even pentadecagons!

regular polygons



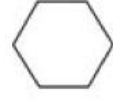
triangle
3 sides



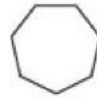
quadrilateral
4 sides



pentagon
5 sides



hexagon
6 sides



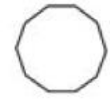
heptagon
7 sides



octagon
8 sides



nonagon
9 sides



decagon
10 sides



How to create your own AR hexagon puzzle?

You will need:

- paper/plastic/wooden shapes

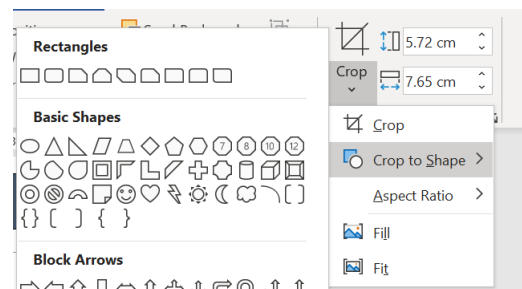
I'm using DIY mirror decoration tiles that I've found in my craft drawer (find them [here](#))

- markers or printed labels

You will be able to arrange 1 big triangular image and 2 smaller ones. They can follow the story theme or different parts of the process (water cycle is a great idea)

In the first step, you need to carefully measure your hexagons to define measurements for each of the three triangular images. Next step is designing, which can be done digitally or by hand. Make sure you add enough detail on each of the triangles for the scanning software to be able to recognise it.

***Useful tip:** Microsoft Office Word or PowerPoint offer a picture formatting option to crop in a specific shape. Use it to create your own triangle-shape images.



When hexagons are ready, arrange them in all possible positions and take photos of each. You will cut those photos into a triangular shape and add to Blippar as a trigger image.



Next step can be as easy or complex as you like – it depends on the digital overlay you choose. In your Blippar builder dashboard, add any text, multimedia or functional buttons that can enrich your learning activity (see the section above about creating overlays) and test, test, test.

Assign a test code for each overlay (if it is on the same trigger, you will be able to achieve seamless differentiation) for your students to access. Enjoy the learning activity and remember to ask your students for their creative ideas – best outcomes come with application of knowledge.



Additional ideas

Exploring and learning is fun, but now it's time for another challenge.

Create your own rhymes with a little help of rhyming cards. Make your own cards or use ready templates by Karyn (find them [HERE](#)).

Turn your rhymes into media:

- record them like a song
- make an illustrated visual
- create a video

or just use your text to overlay your rhyming cards!

And don't forget – share them with friends!

Tutorials on how to overlay images with media in AR are available [HERE](#)



Pyramids and Prisms - FlashOBJECTS

Using geometric shapes to overlay extra information on top of symbols is not a new idea, flashcards have been around forever. However, what is changing is the importance these retrieval methods are gaining in classroom teaching practice.

Retrieval practice is the act of trying to recall information without having it in front of you. Imagine you are studying the systems of the human body—skeletal, muscular, circulatory, and so on. You could do retrieval practice by attempting to name those systems without looking at the list. Once you have listed all you can remember, you would open up your book or notes and check to see if you got them right. In recent years, cognitive psychologists have been comparing retrieval practice with other methods of studying—strategies like review lectures, study guides, and re-reading texts. And what they're finding is that nothing cements long-term learning as powerfully as retrieval practice. Read more about it, download resources or strategies [HERE](#)

Using AR can make your flashcards interactive and fun, but also, it adds another action between recall and checking the answer. In other words, we need to put more effort into discovering the answer, and we might try harder to remember the answer ourselves before we scan the marker. Now, turning our flashcards into FlashOBJECTS makes the whole learning process more interesting. Starting with the process of organizing content and creating own flashobjects, students are engaging with the newly acquired knowledge and summarize it creatively while developing their digital skills. The element of fun and discovery in using AR with smartphones and tablets motivates students to use these objects frequently, as well as to share them or show them to their colleagues. After a while, like with regular flashcards, students store that information in their long-term memory and no longer need cards or objects to aid the information recall. That's when the learning object becomes an artifact representing certain content, and can be used to lead the initial discovery for other students.

To make your FlashObjects you will need:

- a paper template for the object you choose (many object can be found [HERE](#))
- markers to write/draw on your objects

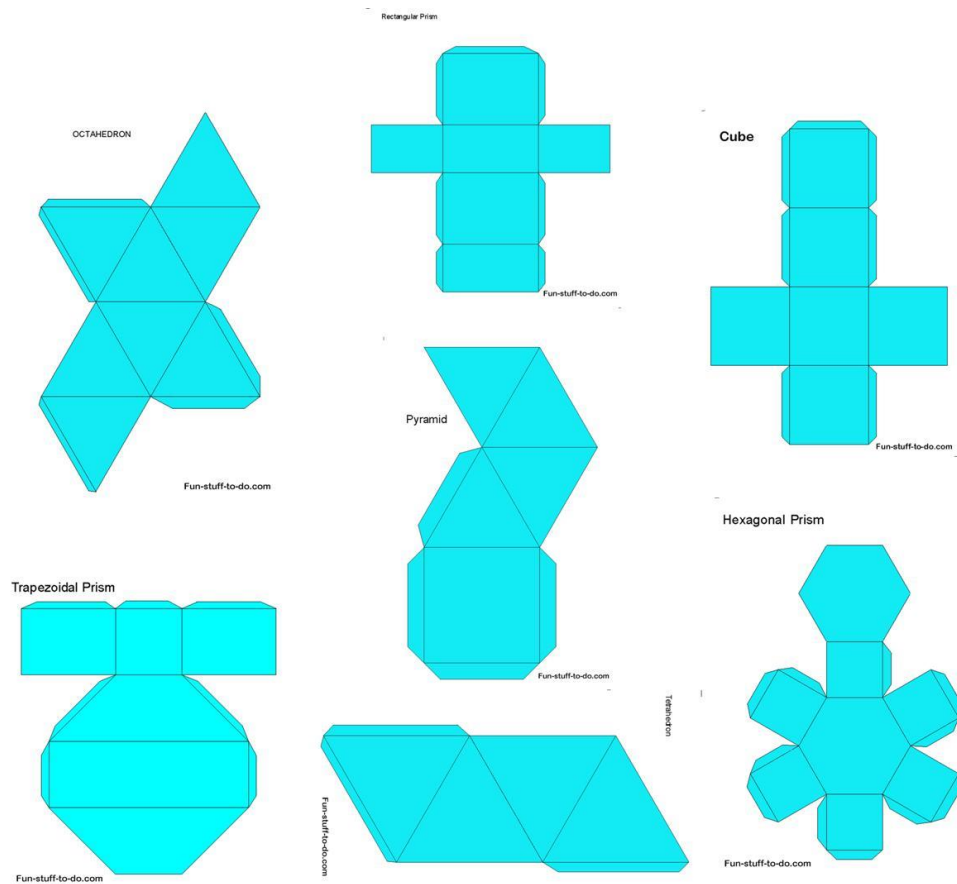
When the design of your object is ready:

- print it out
- fold/glue/arrange it in all possible positions
- take photos of each position (or if designed digitally, skip this step)
- add each photo (or digital image) to Blippar as a trigger image

Next step can be as easy or complex as you like – it depends on the digital overlay you choose. In your Blippar builder dashboard, add any text, multimedia or functional buttons that can enrich your learning activity (see the section above about creating overlays) and test, test, test.

Assign a test code for each overlay (if it is on the same trigger, you will be able to achieve seamless differentiation) for your students to access. Enjoy!

Example templates:



Folding cube

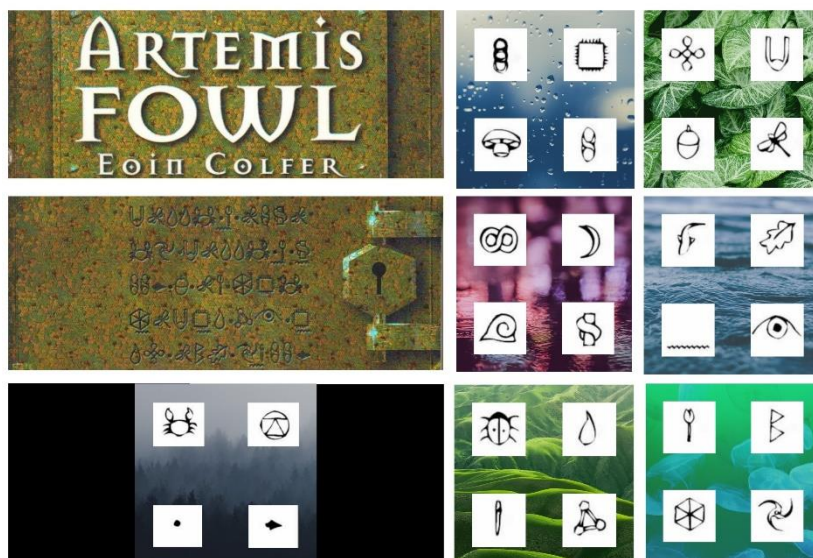


Augmented reality folding cube is an exciting way to introduce discovery learning in your classroom.

Fidgeting toy as a basis for educational materials ensures that all your students (especially students with attention difficulties, sensory or autism spectrum conditions) enjoy learning.

Even with multiple research findings connecting movement with improved focus and academic performance, the importance of kinaesthetic elements is often forgotten in traditional teaching practice. One way of offering your students some kinaesthetic learning opportunities is to use 3D objects as an alternative or addition to your usual printed instructions or tasks.

How to create your own AR folding cube?



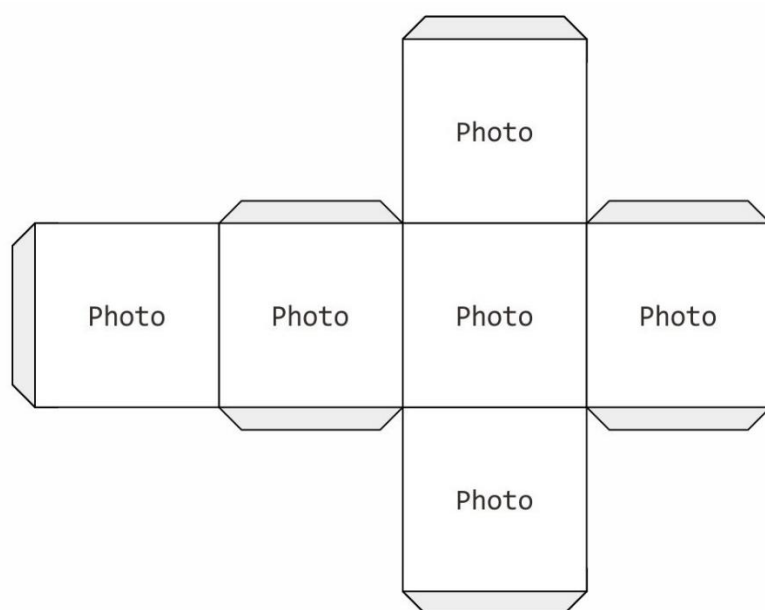
You will need:

- square labels
- I'm using 37x37mm square labels sheet from the [Label Planet](#)
- template to print out images on your labels
- Also available on the [Label Planet](#) site
- printer (laser or inkjet, it works on both)
- some transparent tape
- quite possibly some patience

Start with deciding on the images you want to have on your AR folding cube. Each cube has 6 square sides and 3 long (or double square) sides. Of course, depending on your content, you can rearrange your sides – double square can be in portrait or landscape orientation; squares can be full or split into smaller images. Above is an example of my template.

Next step is to print out the labels (make sure you rotate the blank labels correctly when placing them in the tray) and the paper cube templates (each infinity cube is made of 8 cubes). Here is where the patience comes in. You might need a few extra sheets of labels to practice, so count that in.

Now to create the shapes in paper – the folding cube design is composed of 8 identical paper cubes. You can use the blank template below and add printed stickers on the finished construction, OR carefully plan the position of each side of each cube and print the image segments prior to cutting. Either way, you will need 8 of these templates, printed in the same size. If you are using the stickers, make sure that each sticker corresponds to the size of the cube faces.



Connecting individual paper cubes right is crucial for a folding cube to work. Use tape to connect the individual paper cubes, but follow the video tutorial to make sure you get it right:

https://youtu.be/m_fpkmAIEYQ

Once the cubes are connected into a folding cube design, you can add stickers on faces of the object to create the illusion of hidden images. When you connect your cubes and add labels it should look something like this:

<https://twitter.com/i/status/1143409881808035841>

The only thing left to do is to make this infinity cube interactive. Depending on your skill level, pick your AR elements from Blippar builder and add another dimension of content. Tutorials on how to overlay images with media in AR are available in the first part of this tutorial.



Enjoy your kinaesthetic learning!

Get creative!

Augmented reality folding cube is an exciting way to introduce discovery learning in your classroom. Fidgeting toy as a basis for educational materials ensures that all your students (especially students with attention difficulties, sensory or autism spectrum conditions) enjoy learning. Even with multiple research findings connecting movement with improved focus and academic performance, the importance of kinaesthetic elements is often forgotten in traditional teaching practice. One way of offering your students some kinaesthetic learning opportunities is to use 3D objects as an alternative or addition to your usual printed instructions or tasks.



References

- WU, H., LEE, S., CHANG, H. and LIANG, J., 2013. Current status, opportunities and challenges of augmented reality in education. *Computers & Education*. 62, pp. 41-49.
- SHEEHY, K., FERGUSON, R. AND CLOUGH, G., 2014. *Augmented education*. New York: Palgrave Macmillan.
- RADU, I., 2014. Augmented reality in education: a meta-review and cross-media analysis. *Personal and Ubiquitous Computing*, 18(6), pp.1533-1543.
- MILGRAM, P., TAKEMURA, H., UTSUMI, A. and KISHINO, F., 1995. *Augmented Reality: A class of displays on the reality-virtuality continuum. Telemanipulator and Telepresence Technologies*. 2351(1), pp. 282-292.
- DI SERIO, Á., IBÁÑEZ, M. and KLOOS, C., 2013. Impact of an augmented reality system on students' motivation for a visual art course. *Computers & Education* [online]. 68, pp. 586-596. [Accessed 9 April 2020].
- BUJAK, K., RADU, I., CATRAMBONE, R., MACINTYRE, B., ZHENG, R. and GOLUBSKI, G., 2013. A psychological perspective on augmented reality in the mathematics classroom. *Computers & Education*. 68, pp. 536-544.