



Level 2 **AR/VR**

Student Handbook

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Lesson 1
**Working
with XR**

01. OVERVIEW

You have learnt about the concept of eXtended Reality (XR), how to interact with the digital world, and applications of XR in various sectors.

In this section, you will learn how to work with XR. We will take a look at the terminologies commonly used in XR – immersion, rendering, tracking, etc. Our discussion on the project cycle will make you acquainted with the steps involved in creating a basic augmented reality setup. You will also get a chance to exercise your skills in an activity where we will create our first XR application!

1.1. Learning Objectives

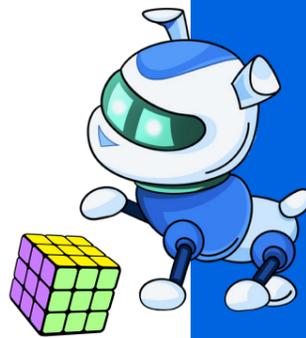
At the end of this unit, you will be able to:

- Understand the terminologies used in XR
- Learn the basic steps involved in creating an XR project
- Learn the algorithm behind an XR application

02. XR GLOSSARY

XR is now a part of our daily life. Therefore, it is important to stay updated with the basics of XR. As we delve into the details of the workflow of XR, let us start with the commonly used terms and acronyms. Given below is a glossary of terms extending across the immersive technology spectrum. But first, let's do a quick activity!

ACTIVITY MATCH THE FOLLOWING



Match the definitions in column A with the appropriate terms in column B.

Column A	Column B
i. Adds digital elements to a live view	1. Virtual Reality (VR)
ii. An experience that completely shuts out the real world	2. Mixed Reality (MR)
iii. Interaction of real-world and digital objects	1. eXtended Reality (XR)
iv. Umbrella term covering all the digital technology which enhance our senses	4. Augmented Reality (AR)

180° Video

Videos showing 180° of a scene from the user's point of view.



360° Video

Videos showing 360° of a scene from the user's point of view.



3D Animation

Creating a sequence of poses with a 3D object that creates the illusion of life-like movement.



Avatar

A virtual representation of an individual that may have life-like or animated features and that can convey a sense of one's identity.

Degrees of Freedom

Refers to the different degrees of movement available to an object in a space. Common XR devices have 3 DoF or 6 DoF.



Eye Tracking

A process used in headsets to track movement of the user's eyes.

Head Tracking

A process used in headsets to track movement of the user's head.

Head Mounted Display (HMD)

A hardware unit – e.g., a VR headset – worn on the user's head that provides the vehicle to visualize and immerse in virtual worlds.

Haptics and Force Feedback

Feedback to the users in order to simulate real-world touch and force to make the interaction more real.

Markers

A code which triggers XR experiences to appear on any device.

Resolution

Resolution refers to the degree of detail an image holds. Higher resolutions make images sharper, which adds more detail to them.



QR (Quick Response) Codes

A matrix barcode that contains digital information about an item, object, person, place, or location. Activated by a smartphone camera, the code pulls up the linked information.

WebXR

Immersive content accessed directly through the web browser without an app.

03. AR APPLICATION ALGORITHM

ACTIVITY BRUSHING ALGORITHM

Have you ever paid close attention to your routine of brushing teeth? What are the steps involved? What do you do in the beginning? How do you finish this daily morning ritual?

Try to write down the step-by-step instructions you follow to brush your teeth. Be as specific as possible. Do you think someone can accomplish this menial task if they religiously follow your instructions? Try it out with your family at home.

See this [video](#) for reference.



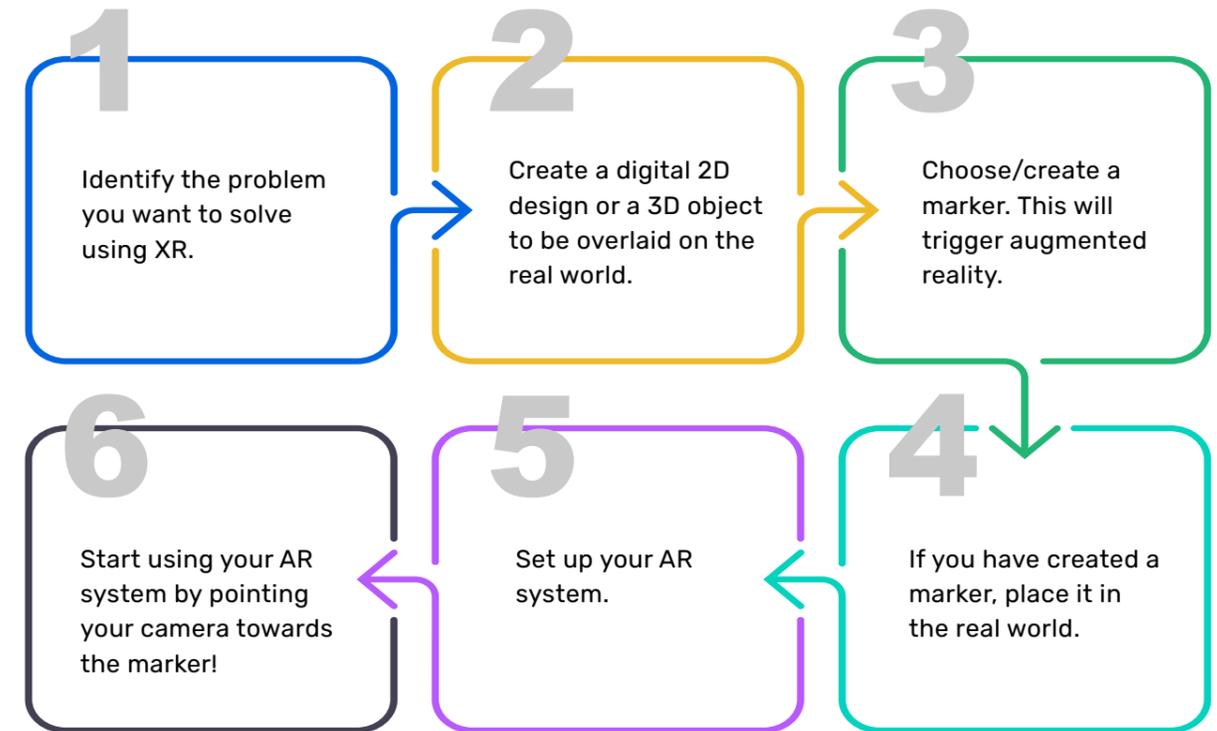
The outcome of the above activity is what an algorithm looks like. It is a set of instructions for solving a problem or accomplishing a task. A common example of an algorithm is a recipe, which consists of specific instructions for preparing a dish or meal.

The exact algorithms to create AR, VR, and MR differ for each technology respectively, and their discussion is beyond this course. However, we would be focusing on creating a basic AR application.

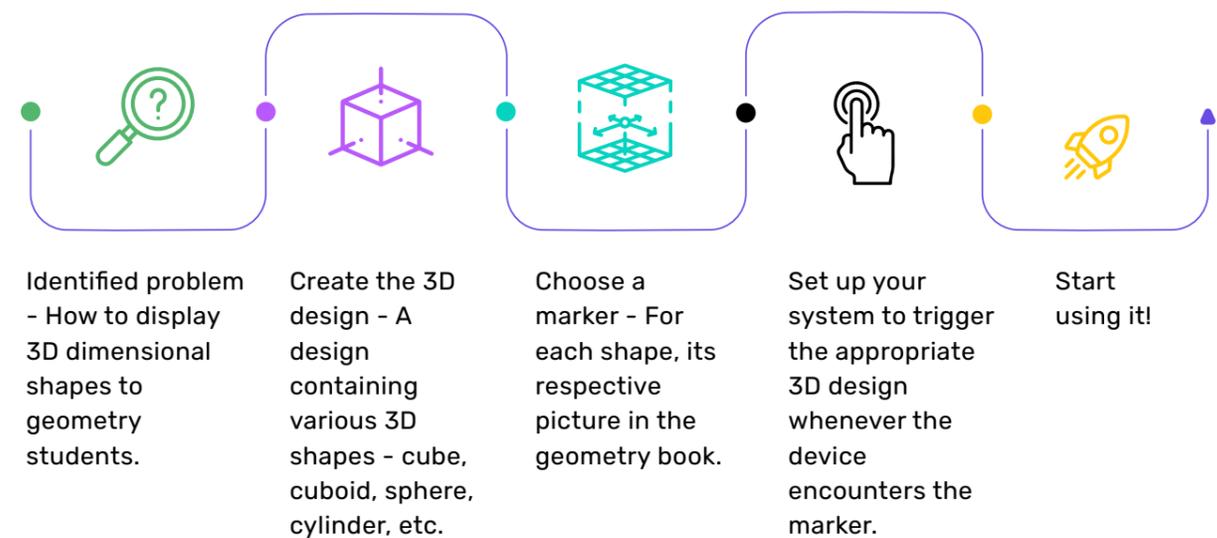


ACTIVITY

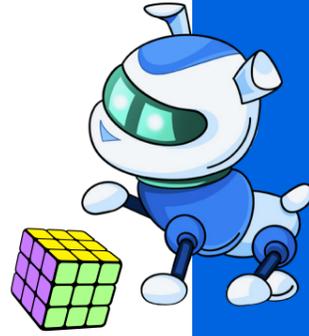
Here is a graphic displaying the step-by-step process of creating a marker-based AR application.



Here is a sample algorithm for an AR application which displays machine temperature.



ACTIVITY
AR APPLICATION ALGORITHM



By now, you must have started thinking of all the ways you can use AR! This activity will provide you a chance to get into the shoes of an AR developer and write an algorithm to create a system of your own.

Start thinking: Can we use AR to display the temperature of a machine, or the recipe of a dish we eat at the restaurant, or the information about products in a store?

Write down the step-by-step instructions.

ACTIVITY

NOTES

Lined area for taking notes, consisting of multiple horizontal dotted lines.





Lesson 2
**Design
Thinking
with XR**

01. OVERVIEW

In this section, you will learn about innovating using design thinking. One of the most sought-after design processes. Design thinking is used by innovators world over to identify challenges and overcome them using creative solutions. We will undergo the 5 stages of design thinking and learn tools and techniques to apply them to build out of the box solutions. At the end of this section, you will get a chance to use your learnings to come up with an eXtended Reality (XR) solution for an identified problem.

1.1. Learning Objectives

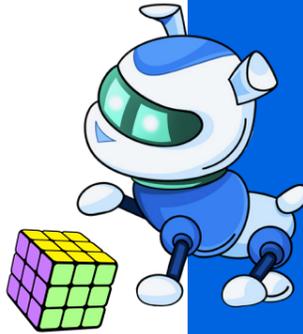
At the end of this unit, you will be able to:

- Understand design thinking
- Learn the 5 stages of design thinking
- Learn how to apply design thinking with XR

02. INNOVATION AND DESIGN THINKING

ACTIVITY OUT OF THE BOX

We constantly face many challenges in our lives. Take a look at the images given below and discuss with your classmates the challenges that these products intend to overcome.

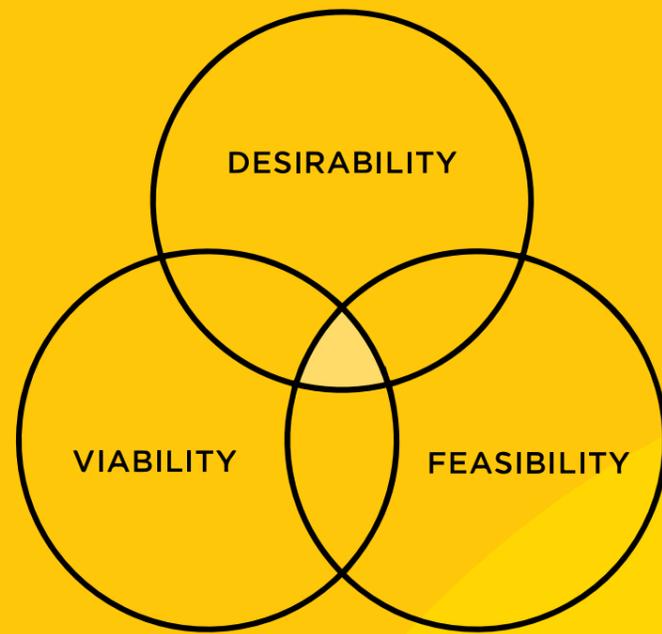


Do you think these products are different from the ones we use daily? How do you think someone might have come up with these “Out-of-the-Box” ideas?

Design thinking is a process that helps to understand users, challenge assumptions, redefine problems and create innovative solutions to prototype and test. By using design thinking, you make decisions based on what your users really want instead of relying only on historical data or risky bets. It also brings together what is desirable from a human point of view with what is technologically feasible and economically viable.

When applied to XR, it equips us to understand how to design new virtual experiences for the user. It is essential to develop a design thinking mindset for creating XR applications.





Design thinking is a human-centered process which is almost certainly the best creative process for "thinking outside the box".



Design thinking has led to numerous innovative and creative solutions all over the world! Take a look at the videos below to understand how useful this process can be.

Watch this heart-warming [video](#) of an innovative solution by kids to keep their fathers from over speeding.



Here is another story of how used [plastic bottles are used as light bulbs in London.](#)



03. 5 STAGES OF DESIGN THINKING

The [design thinking process](#) has 5 stages – Empathise, Design, Ideate, Prototype, Test. We must remember that it is not a linear process but a circular one – we can move between different stages in any order, depending on our needs. Let us go through and understand all the 5 stages using a hypothetical case study.



STEP 1: EMPATHISE

To identify or understand what our users see, feel or experience, in order to relate to the problem that others might be facing.

During this stage, we need to list down the pain points experienced by our user.

Example:

Theme: Water scarcity

User: Citizens who need to fetch water from a long distance.

Pain points:

(Put yourself in the shoes of the user. Now, think and write 3 more pain points experienced by the user)

- Carry heavy load on head.
- Walk long distances daily.
- Spinal injuries due to heavy load.

- _____
- _____
- _____

STEP 2: DEFINE

To analyse the observations from the empathise stage to identify the core problem - out of all the problems which could be solved, which one are we going to choose.

During this stage, we analyse the identified pain points during the empathise stage, and come up with one specific problem statement.

Example:

Problem statement 1: How might we help the user to move water from the source to their homes?

Problem statement 2: How might we help the user in travelling daily to and from the water source?

Now, can you come up with another problem statement for our user?

Problem statement 3: How might we help

-----?

STEP 3: IDEATE

To use creativity and innovation in order to generate as many solutions as possible, and choose a few of them to move forward.

During this stage, we imagine various solutions to solve the identified problem.

Example:

Possible solutions:

(Think and write 3 more solutions to Problem **statement 1** in previous stage)

- Create a network of canals.
- Hire a truck to carry water.
- Design a water cart which is easy to move.

• -----
• -----
• -----

STEP 4: PROTOTYPE

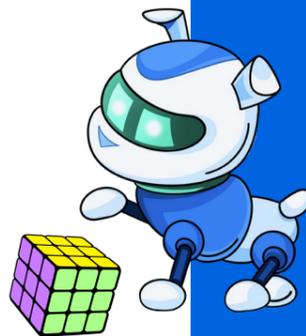
To make the early sample of the chosen solution.

During this stage, we choose one (or a few) solution(s) from the ideate stage and start building them. You can even combine multiple solutions to come up with a super solution!

Example:

Chosen solution: Design a water cart which is easy to move.

Now, can you draw a concept of another solution which you prefer from the last stage?





Lesson 3
**Making
a Mark**

01. OVERVIEW

Here, you will explore the world of markers – the things which trigger your XR. You will learn how information is stored in the QR codes we scan for digital payments and how our cameras read them. This will be followed with a discussion and hands on activity on XR markers and how to create one on our own.

1.1. Learning Objectives

At the end of this unit, you will be able to:

- Learn how to store information through bar/QR codes
- Understand how to create markers for XR
- Try creating markers for XR

02. STORING INFORMATION WITH BARCODES/QR CODES

When you last went to a grocery store or a shopping mall, did you happen to see this image?



Do you know what it's called? Circle the answer that you think is right.

1. Bar Code
2. QR code

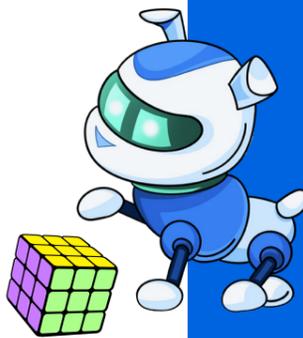
If you chose 2, you are right!

But do you know what 'QR' stands for? Circle the correct answer.

A. Quick Review Code

B. Quick Response Code

C. Quick Reply Code



Barcode	QR Code
A way of storing numbers in a printed and computer understandable format.	Printed representation of data that can be scanned for retrieval of data.
1D or 2D format	1D or 2D format
Stores less information than QR code.	Stores more information than barcode. Used to store multimedia information.
Vertical arrangement of parallel lines.	Arrangement of square dots on square grids.
Stores information horizontally.	Stores information horizontally and vertically.
Based on Morse Code technology.	Based on Morse Code technology.
	



Watch this cool video to see [how QR codes can be used to give an AR experience to the user](#)

Now grab your phone and scan the QR code below on your smartphone to view the Automotive WebAR Experience!



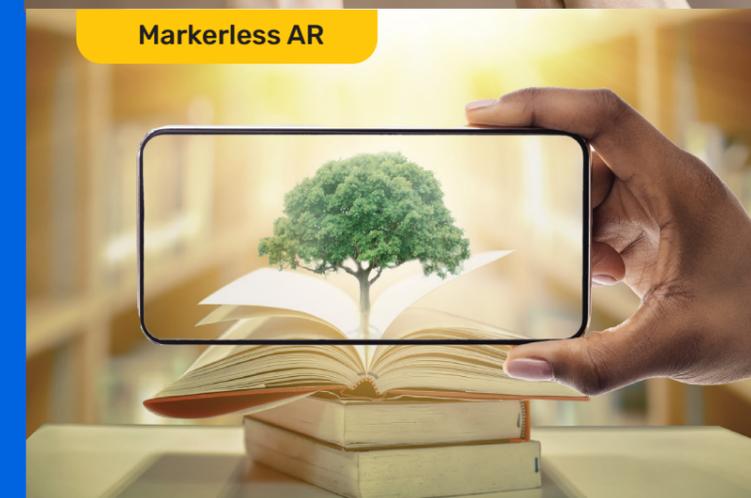
03. XR MARKERS

One of many significant features of XR is how it bridges the gap between the virtual and the digital world in a variety of ways. This makes us understand how we can overlay the digital aspects onto real-world experiences.

Where do we overlay digital content with a live camera?

Where do we place the objects of the content?

To be able to resolve such cases, two popular ways are marker-based and markerless AR.



04. WHAT IS MARKERLESS AR?

Have you shopped online to purchase furniture and tried placing it at a corner in your home? What about the fun Pokémon Go game that brought our childhood memories back? Isn't it fun to see Pokémons in your street or living room? Such experiences are possible with the use of markerless AR through your live camera view.

Markerless AR enables the digital transformation via scanning the scenario or environment without the need of a prompt picture to load the AR content. This feature enables us to try various combinations of objects and styles, and locations.

What is Marker-based AR?

Marker-based AR connects the 3D model object to a real-world object. The AR application overlays a digital object that is merged to a static image that you can see on a newspaper or a flyer etc. Through the live camera view, the scanner instantly recognizes the static image and displays the result which is a virtual image/object at a suitable position.

What is this static image that enables to show the virtual object?

The motionless picture or design which helps the device recognise which real-world object to tie the AR content to is popularly known as a trigger image or a marker.

Let's learn some more points about marker-based AR:

- An AR application can be used to scan the trigger images with the help of a tablet or smartphone to see the effect.
- Markers can be a bar code, a poster etc.
- The images used as markers can be black & white to keep it distinguished from the background setting.

Forget newspapers or flyers, wouldn't it be cool to have our textbooks with AR experiences with the help of marker-based AR. Watch this cool video to see [how marker-based AR works](#) connecting the 3D objects to real world images.



Marker-based ARs can display information such as video, animations, 3D objects, and more.

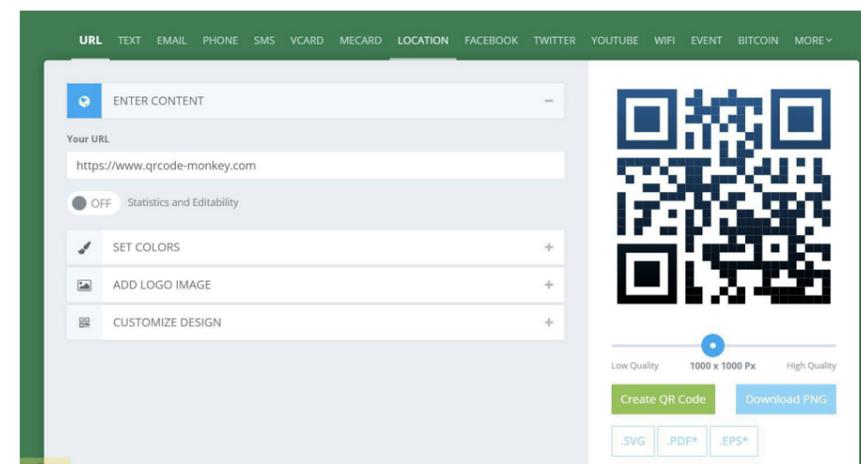
You can try creating your own marker to upload any 3D objects & animations or 2D images, which will help create the AR effect and further upload the static image to the platform which can be used as a marker.

How about trying one right now?

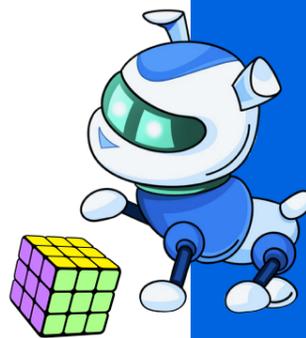
ACTIVITY CREATING MARKERS FOR XR

It's time you try what you have learned. Go to this [link](#) on your device to create your own markerless WebAR through a QR code.

You can design, customise the outlook of the QR code and add a URL of your choice. Once the code is ready you can share it across and see how the QR code redirects you to the website link.



Such QR codes can be designed for markerless and marker-based AR in educational sectors, business, travel etc.



NOTES

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NOTES

Lined area for notes on the right page.





Lesson 4

**Designing for
XR**

01. OVERVIEW

In this section, we will take a look at different ways of designing content for XR applications. You will gain the skill of designing 2D graphics. You can create your own image filters, a virtual greeting card, or maybe a personal signature. You will also get a chance to try your hands on designing 3D models like a modified car model, a futuristic house, etc. to be deployed in the XR space.

1.1. LEARNING OBJECTIVES

At the end of this unit, you will:

- Learn a few ways to convert our physical world into digital objects
- Create a 2D digital graphic
- Create a 3D digital model

02. CONVERTING FROM PHYSICAL TO DIGITAL

ACTIVITY NOW VS THEN

We live in a physical world that is turning more and more digital with every passing day. In this activity, we have listed a few things, which were done physically recently, and have become a part of the digital realm nowadays!

Can you find out what they are similar to in the digital world?

One has been done as an example for you.



PHYSICAL	DIGITAL
Letters	E-mails
Books	
Music CDs	
Maps	
Shops	
School Classrooms	

The above activity will have given you an idea of how things around us, in our physical world, now have counterparts in the digital world too.

But have you ever thought about how this change came about? How do we convert the physical things in our lives into their digital avatars?

Let's take a look at a few methods of going from the physical to the digital.

- **Latest Technology:** New innovations in science and technology have led to rapid digitalization of our world. From ebooks to digital pens, we are surrounded by the latest technology.
- **Typing:** A lot of digital data is created by human beings when we type emails, tweets, WhatsApp messages etc.
- **Sensors:** Sensors help our machines record the happenings of the physical world in a digital format. They can digitise your voice, temperature readings, pulse rate, speed of your car, your weight, and almost anything else.
- **Photos and Videos:** A great way to store our physical world in the digital format is to click photos and record videos.
- **Creating 2D and 3D Graphics:** We can also replicate our physical world in the digital format by creating two- and three-dimensional graphics.

03. 2D GRAPHIC DESIGNING

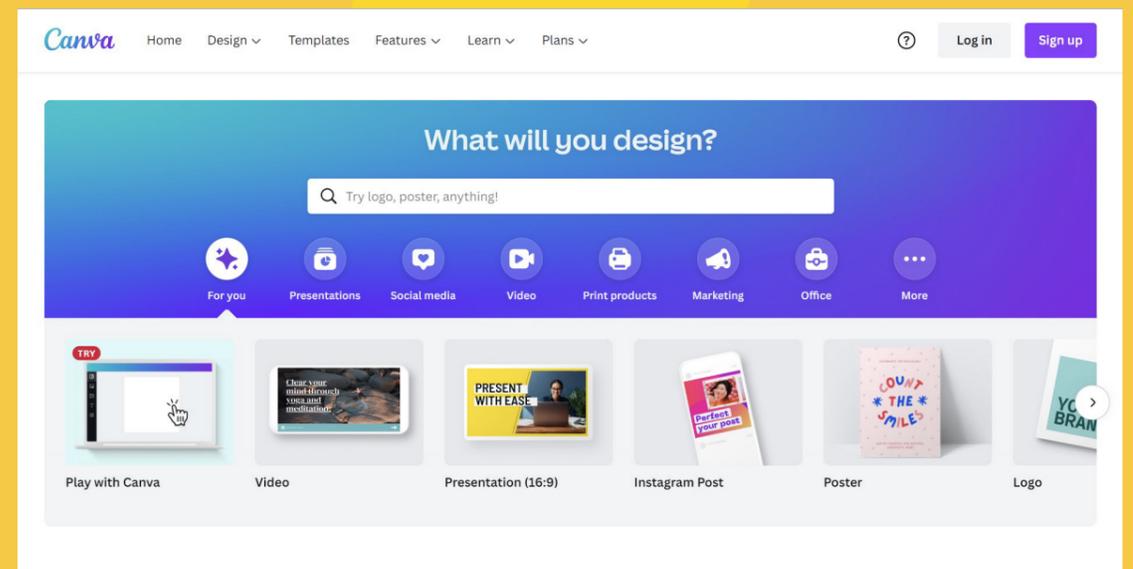
Graphics and animation connect with people on an emotional level, evoking instant feelings of nostalgia, humor, and excitement. There are 2 popular kinds of graphics - 2D and 3D - and both differ from each other in their creation and usage.

2D graphics are computer-generated digital images in 2 dimensions - something like this page that you are reading or the image at the beginning of this section. On a most basic level, they have a height and a width. You must be familiar with 2D graphics in cartoons, video games, and animated films.

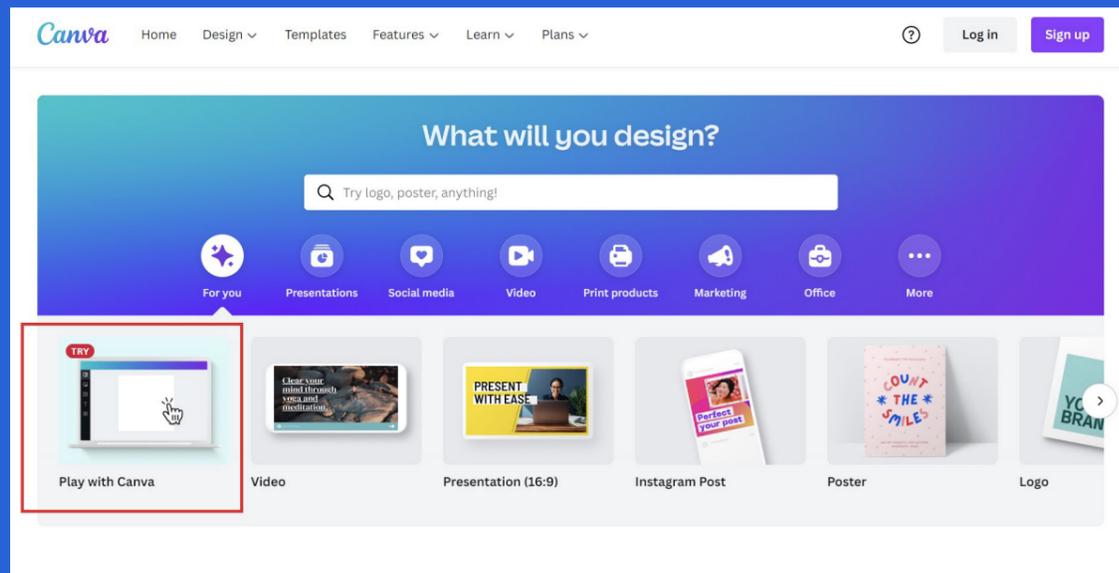
2D graphics can be created through various ways - using digital painting software such as Microsoft Paint, or more advanced software such as Adobe Photoshop, or Canva.

Let us learn how to create a virtual greeting card using Canva.

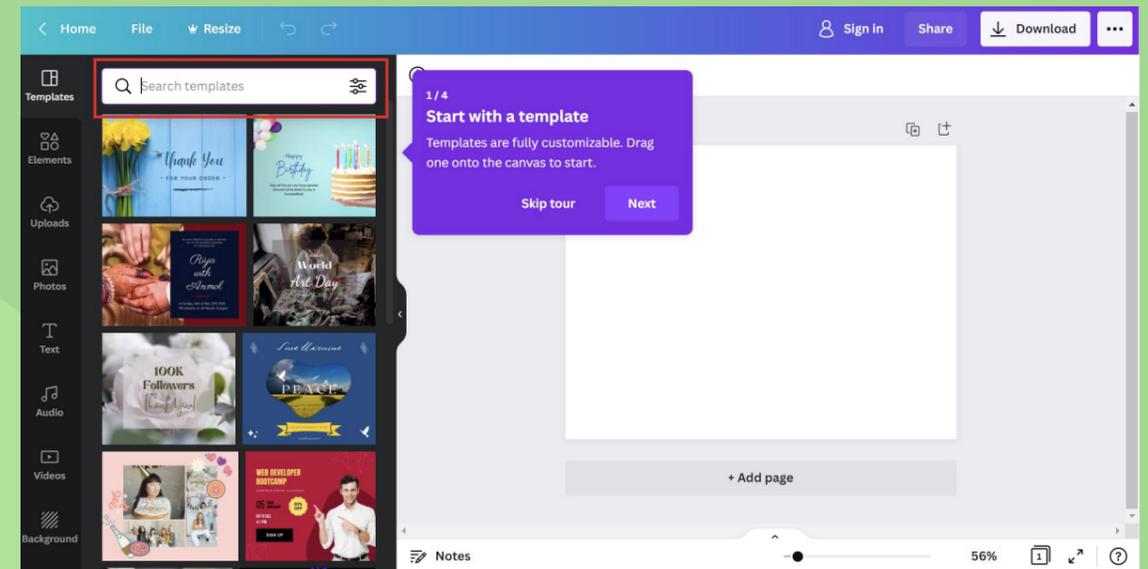
1. Open [Canva](#)



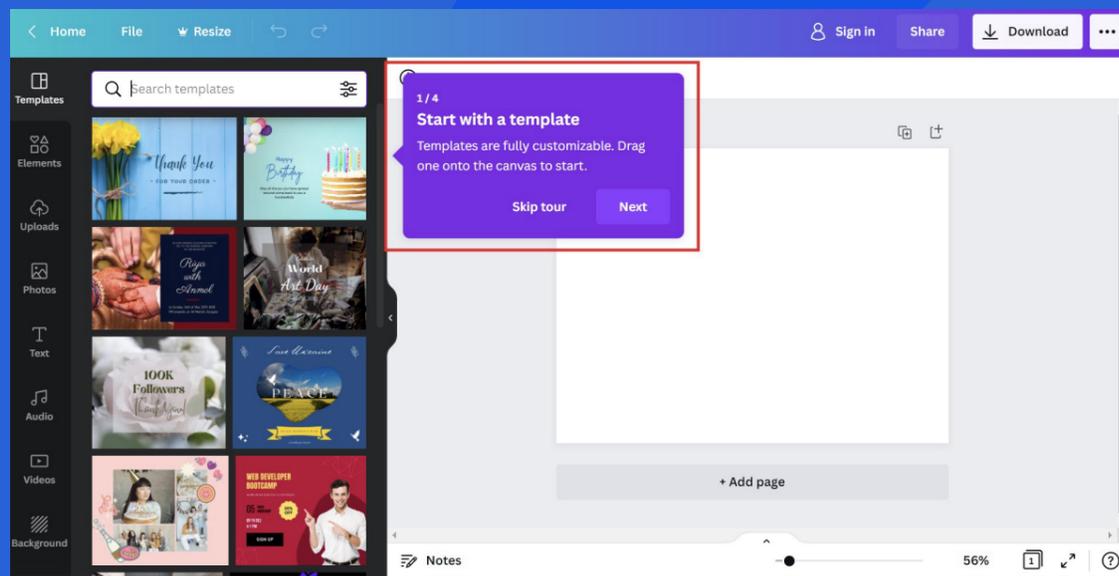
2. 2. Click on 'Play with Canva'.



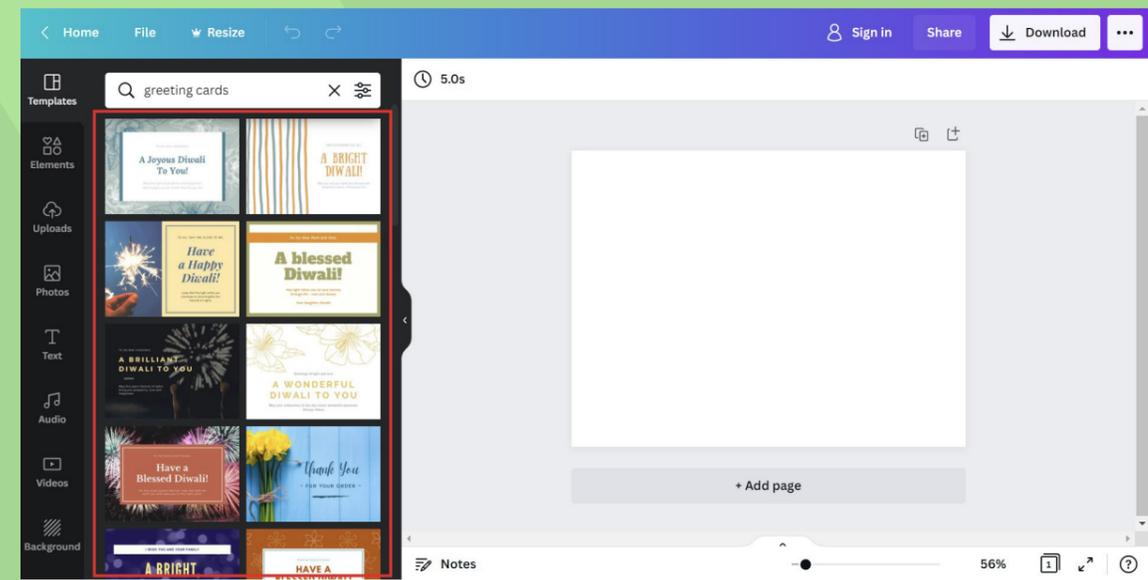
4. Type 'greeting cards' in the 'Search templates' box.



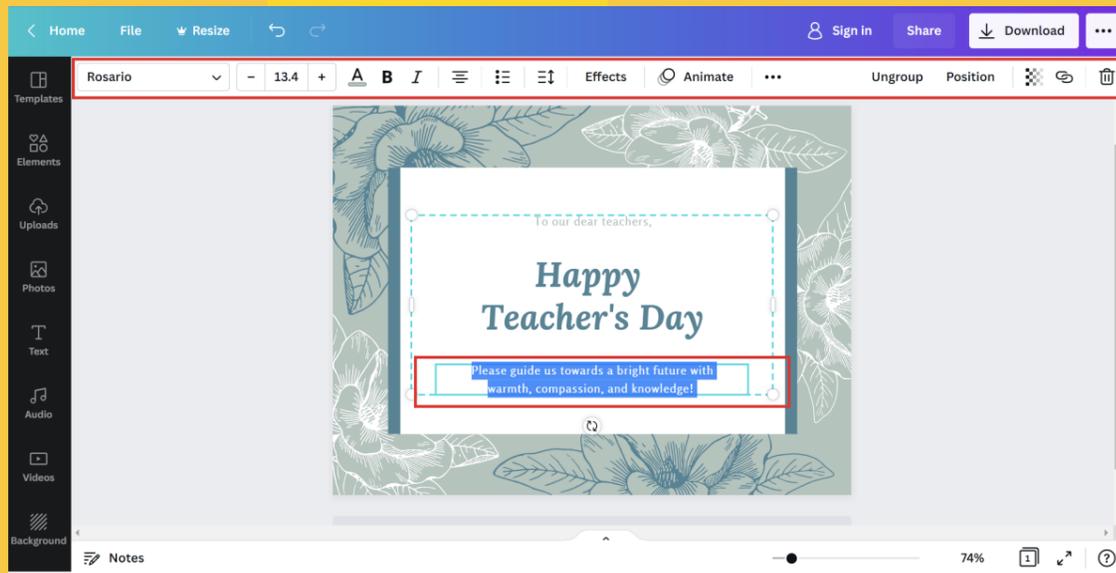
3. Feel free to use the tour to explore the platform.



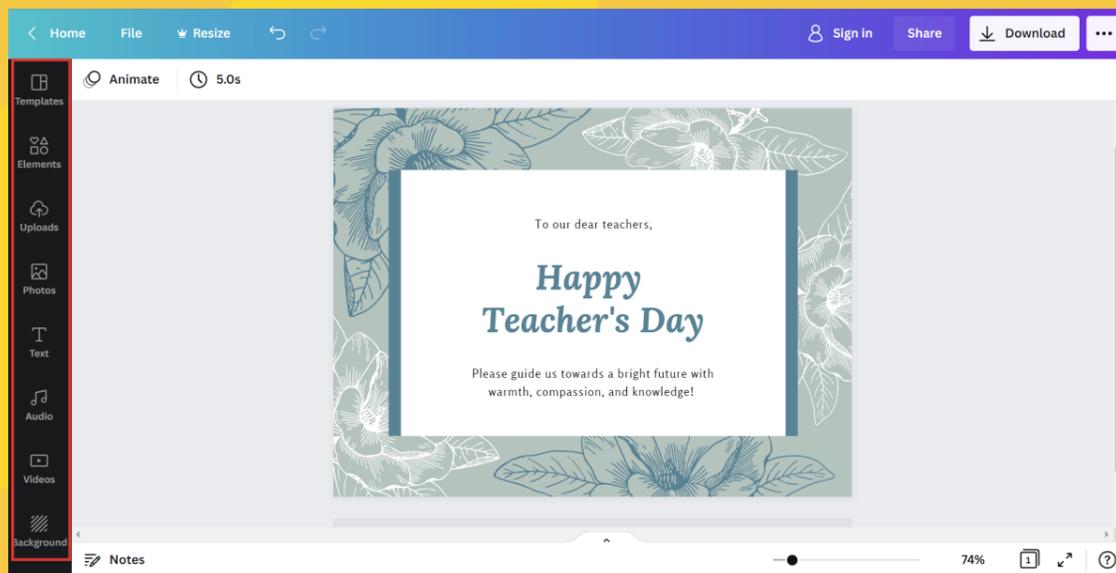
5. Pick any card you prefer from the search results by clicking on it.



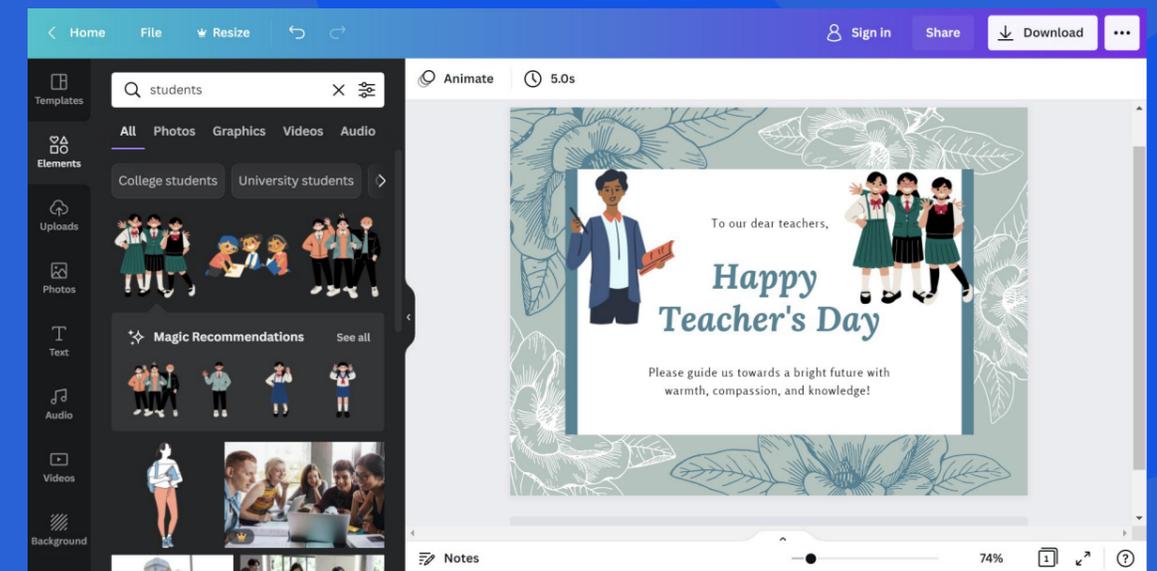
6. Start editing your card by double clicking on the parts you want to edit.
Use the formatting option on the top to edit as you like!



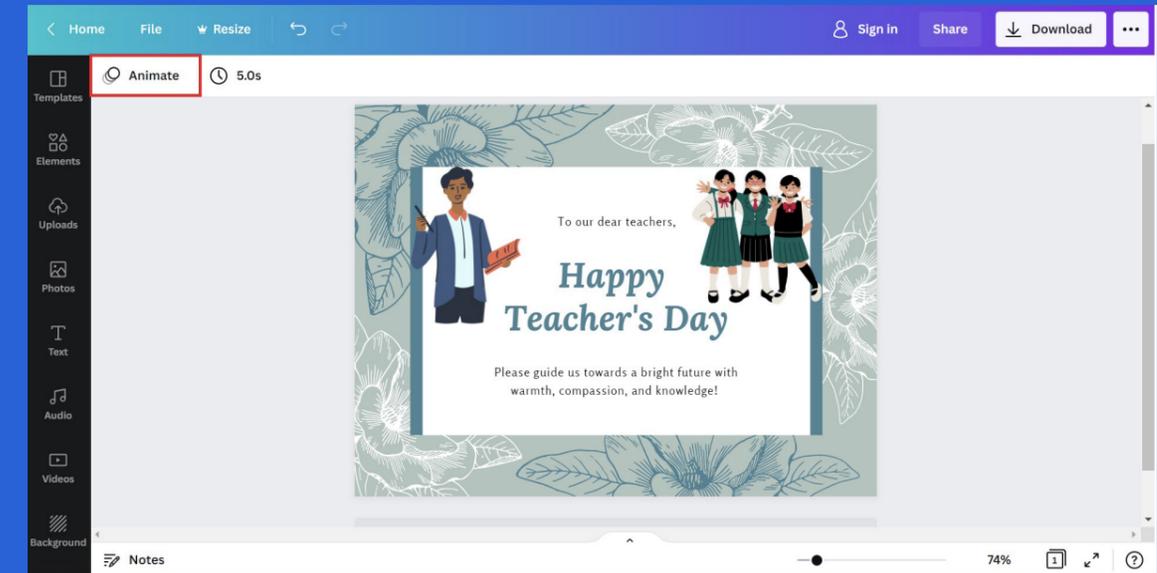
7. Use the option on the left-hand side to add more elements to your design.



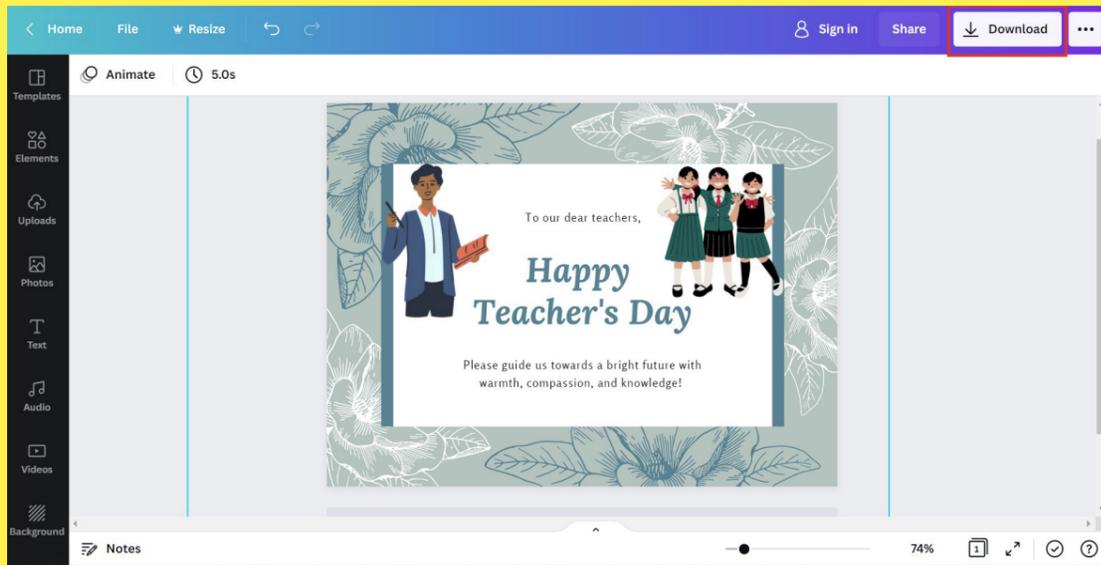
8. Use your creativity to create the card that you want!



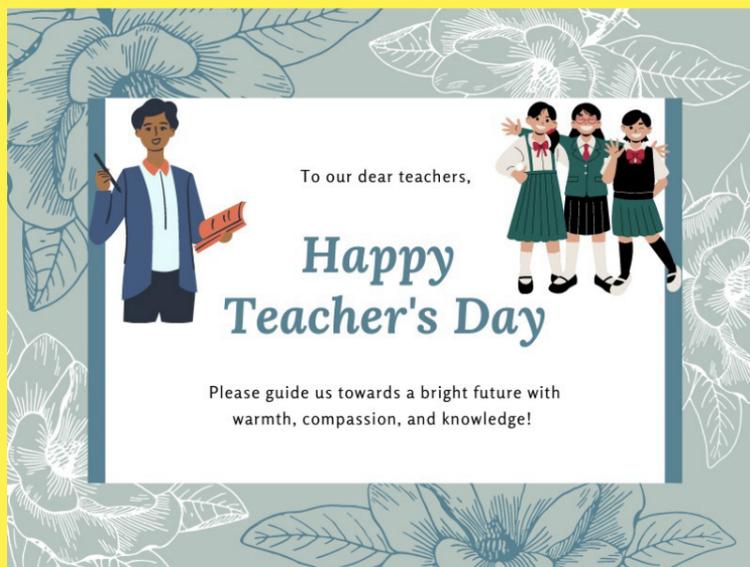
9. Bonus step: You may also animate your graphic by clicking on 'Animate' and adding various stylish animations to your design.



10. Once you are done, click on 'Download' to download your design in the correct format (PNG if you want an image or an MP4 video if you want an animation) on your device and share with friends!

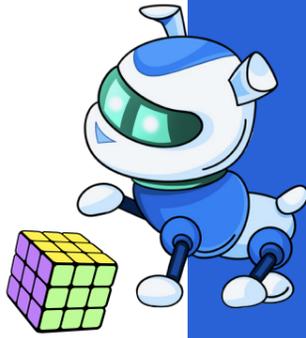


11. Download card.



ACTIVITY INVITATION CARD

We hope you had fun creating that greeting card! Now, how about creating a birthday party invitation card for your friends and families? Put your designer hat on, and get started! Choose a template or start with a blank canvas. Add different fonts, place various elements to create a unique invitation and share!



04. 3D GRAPHICS DESIGNING

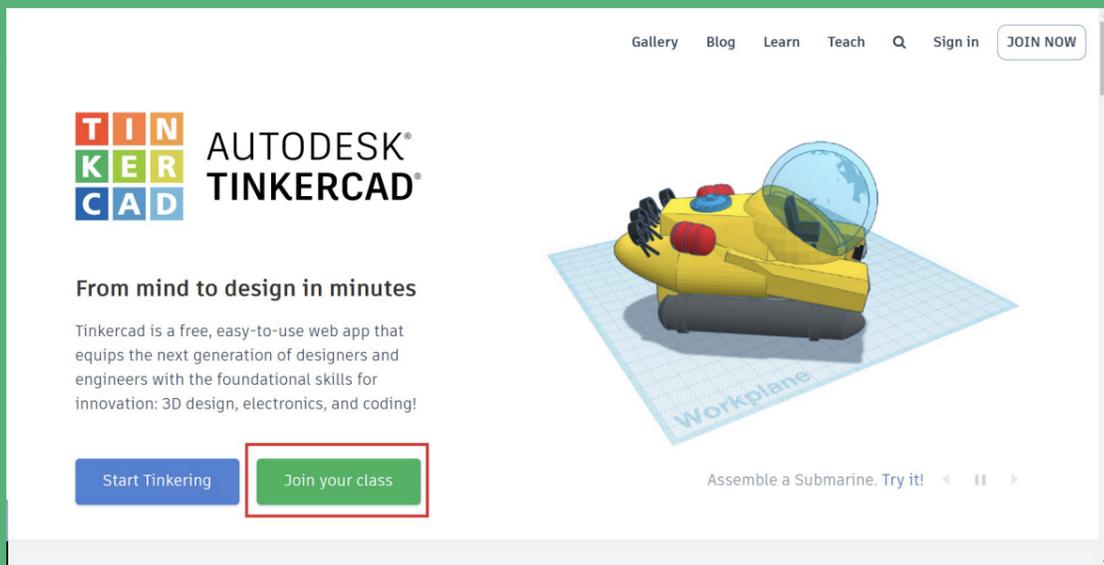
Let's go through a [demo showreel](#) of some intriguing 3D graphics.



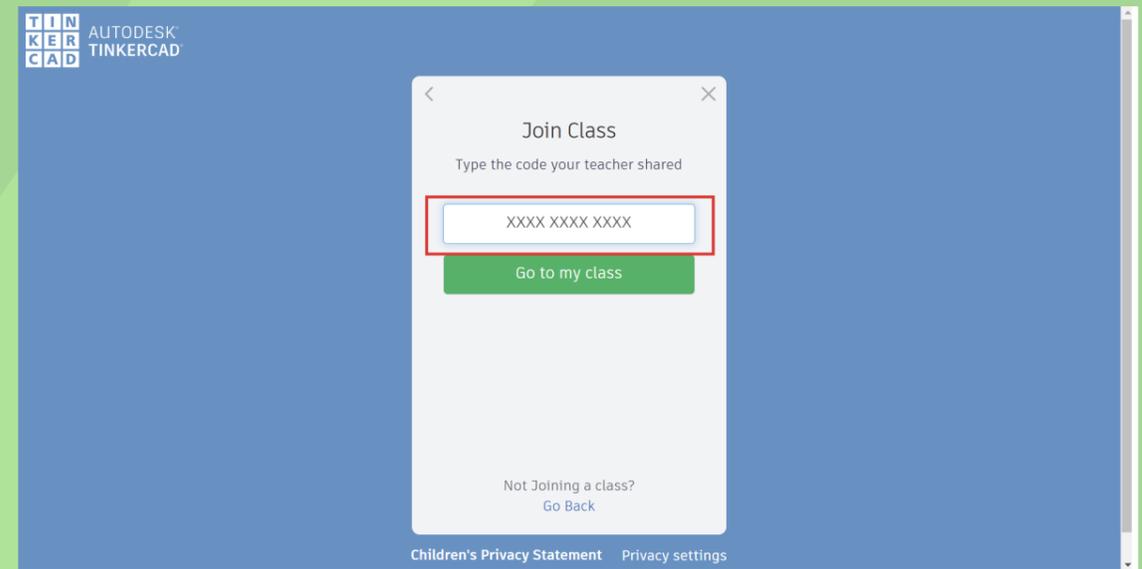
Another type of graphics that we talked about are 3D graphics - the models that you saw in the video at the beginning of this section. In addition to the 2 dimensions of height and width present in 2D graphics, 3D graphics also have a depth. This third dimension makes these graphics feel life-like. They are extensively used nowadays in latest video games, animation movies, and XR applications.

You can create a 3D graphic by using various applications like Microsoft Paint 3D or Tinkercad. Let us learn to create a basic 3D model using the Tinkercad platform!

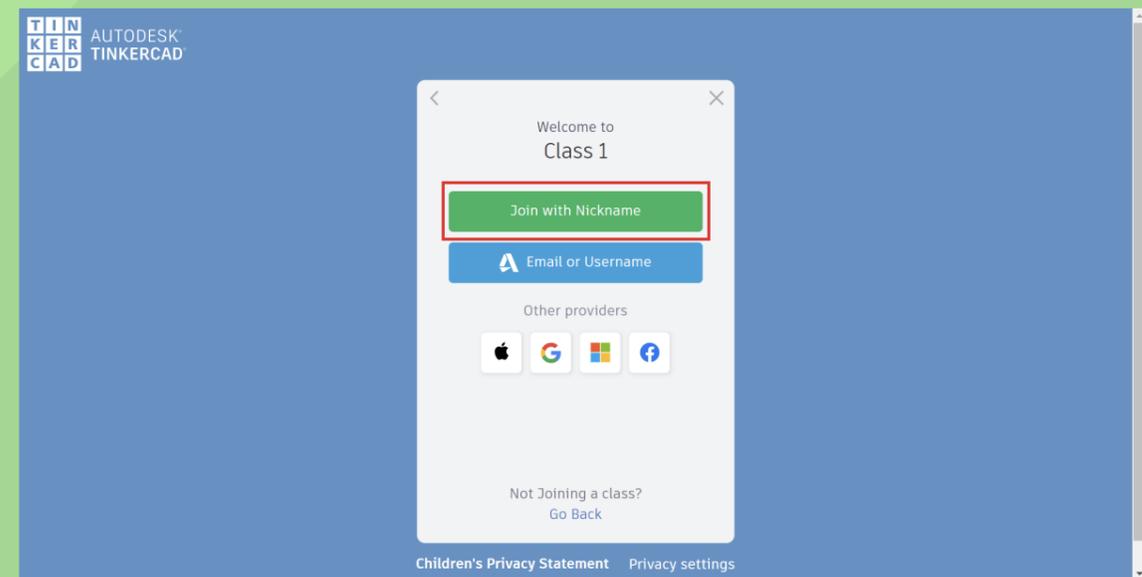
1. Open the platform - [Tinkercad](#) and click on 'Join your class'.



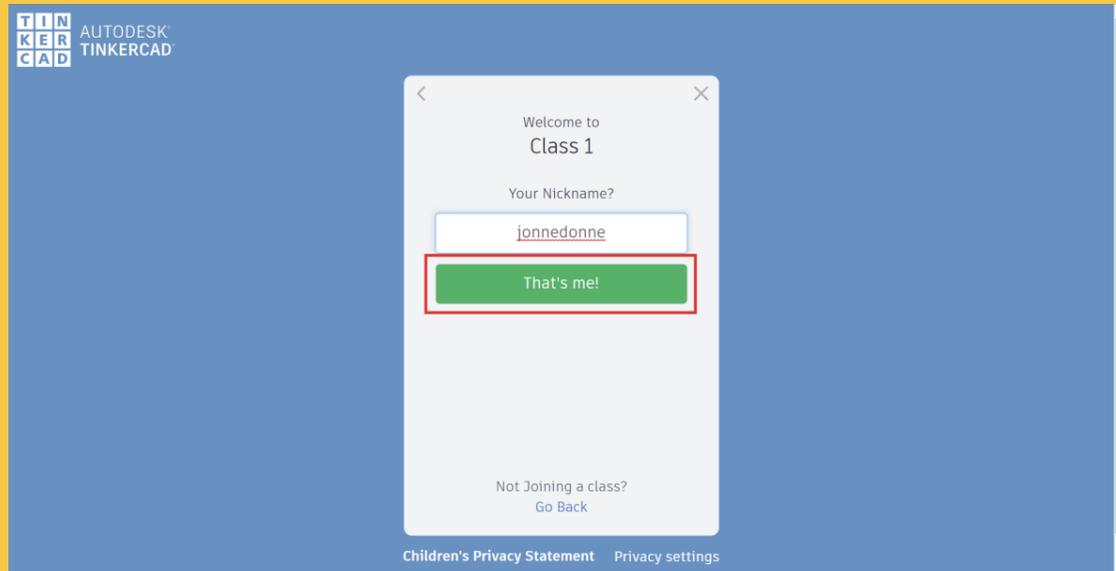
2. Type the class code shared by your teacher.



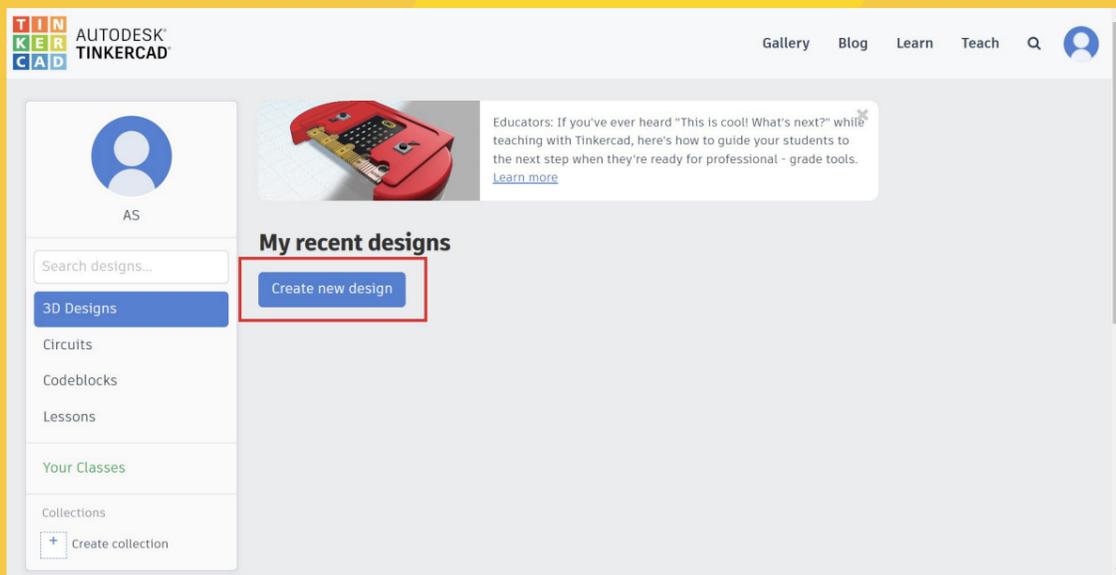
3. Click on 'Join with Nickname'



4. Enter your Nickname (please enter the nickname submitted with the teacher) and click 'That's me!'

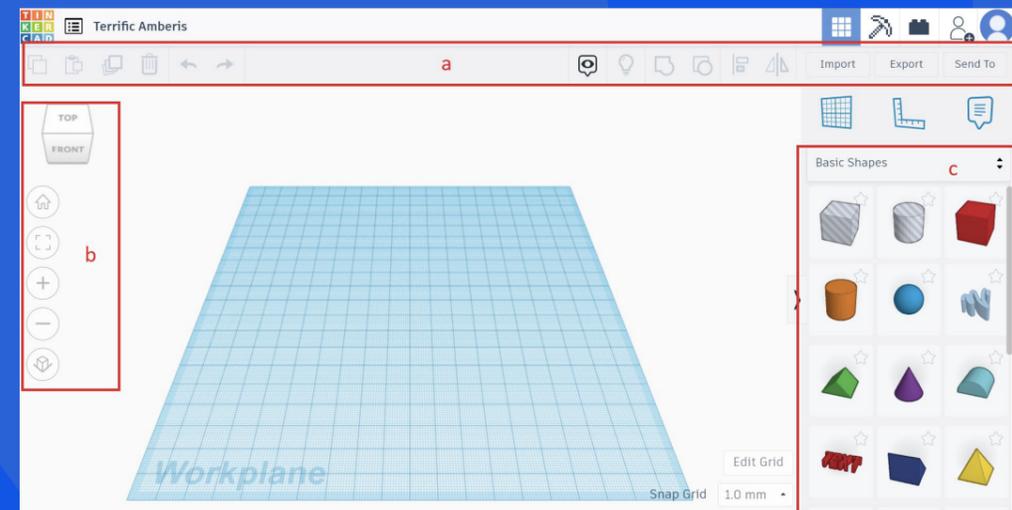


5. When you are in your class, you should arrive at the dashboard. Click on 'Create new design' to get started.

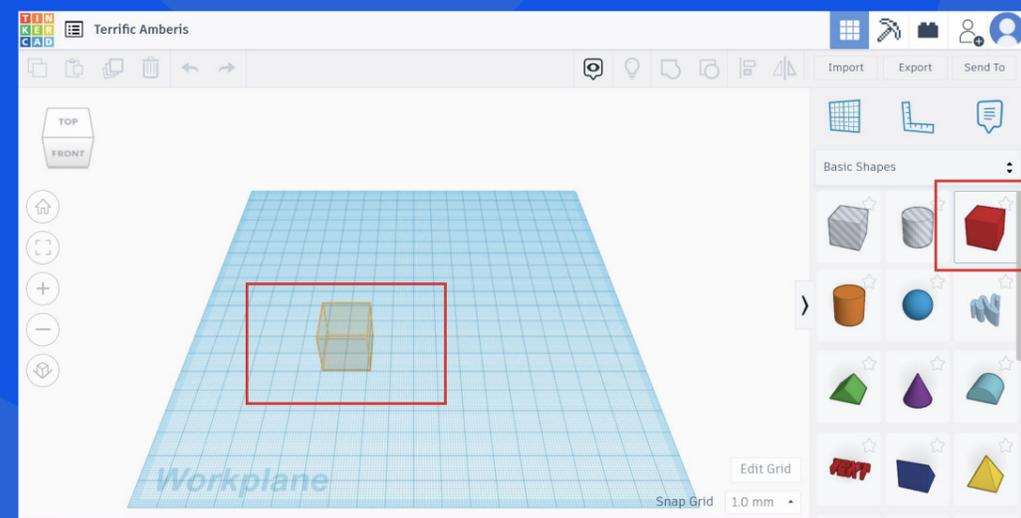


6. This is what a project's main interface looks like. As you would expect, the very center is the "Workplane", upon which models are created and manipulated. The interface is also composed of the following:

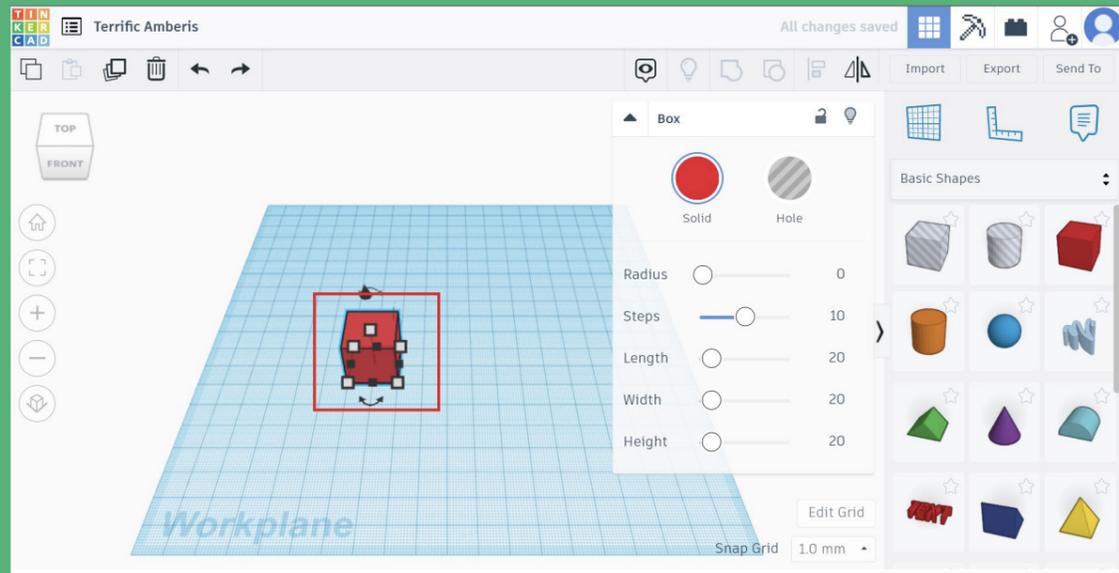
- **Top toolbar**, with more general tools like 'Copy', 'Paste', and 'Delete' on the left and design operations like 'Group' and 'Align' on the right.
- **Navigation tools** for basic orientation like zoom in and out. Note that these specific tools can also be used via mouse (left click, right click, and scroll button).
- **Shape panel**, containing all building blocks for designing, including basic shapes like cubes, spheres, and text. (This can be a fun box to explore, as it has many interesting and sometimes customizable options!)



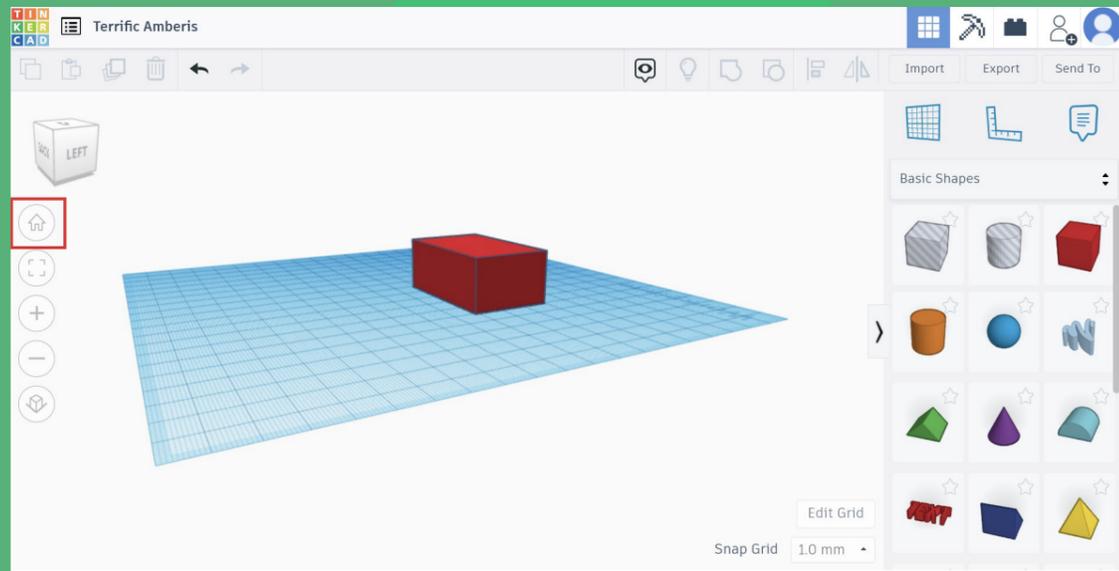
7. Let's begin by selecting a box and placing it on the workplane by clicking at the desired location on the workplane.



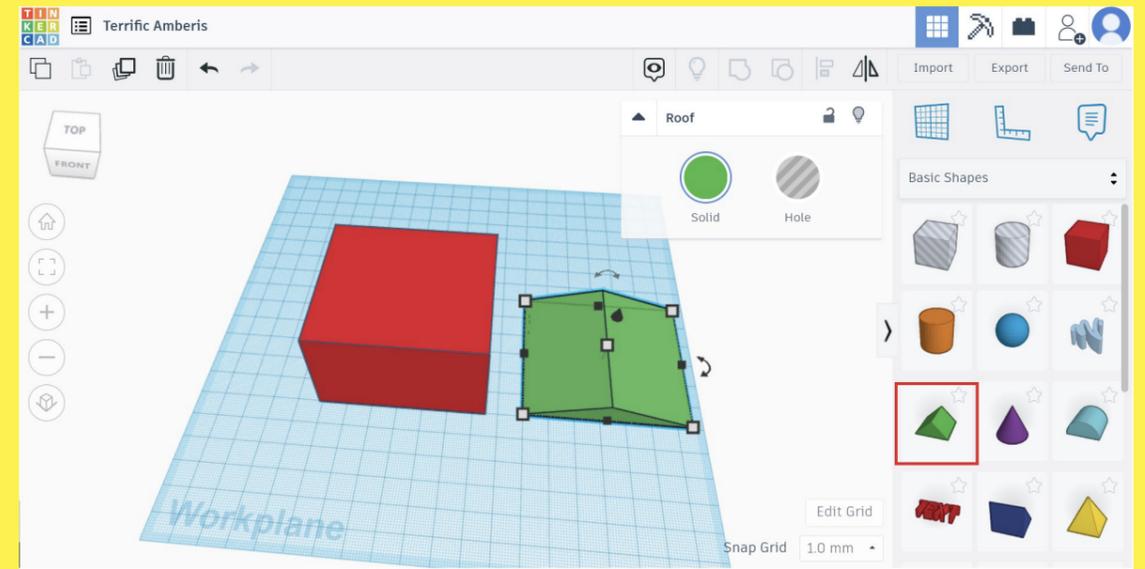
8. You can select the shape by clicking on it. This also allows us to modify the shape by dragging and dropping white coloured square blocks. Try to change the height, width and depth of the box as per your need.



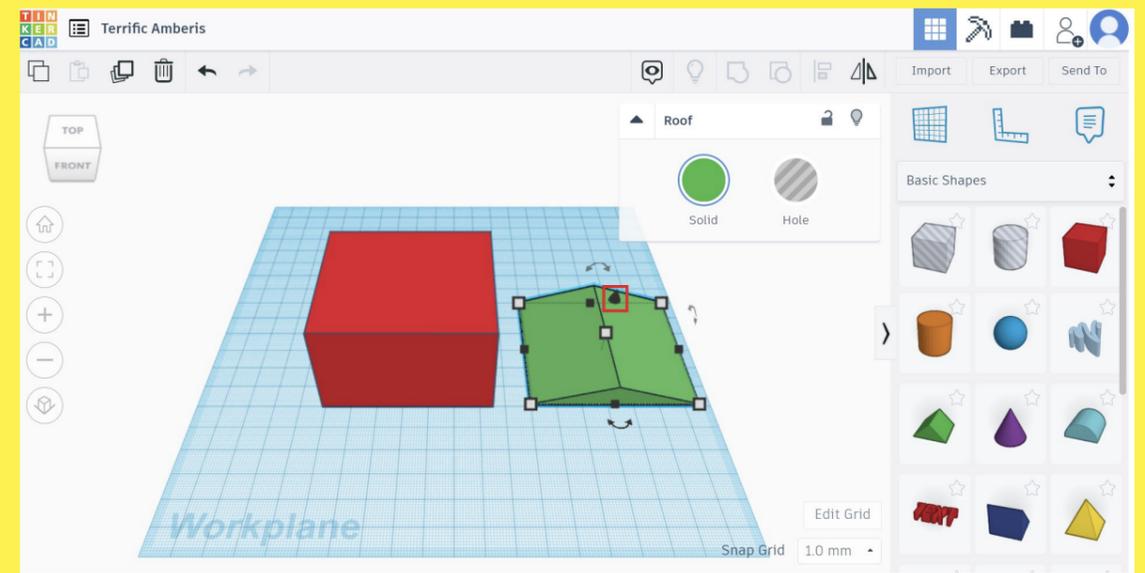
9. Hold down your right mouse button to move around and change the view of the shape. You can click on the home button to go back to the default view.



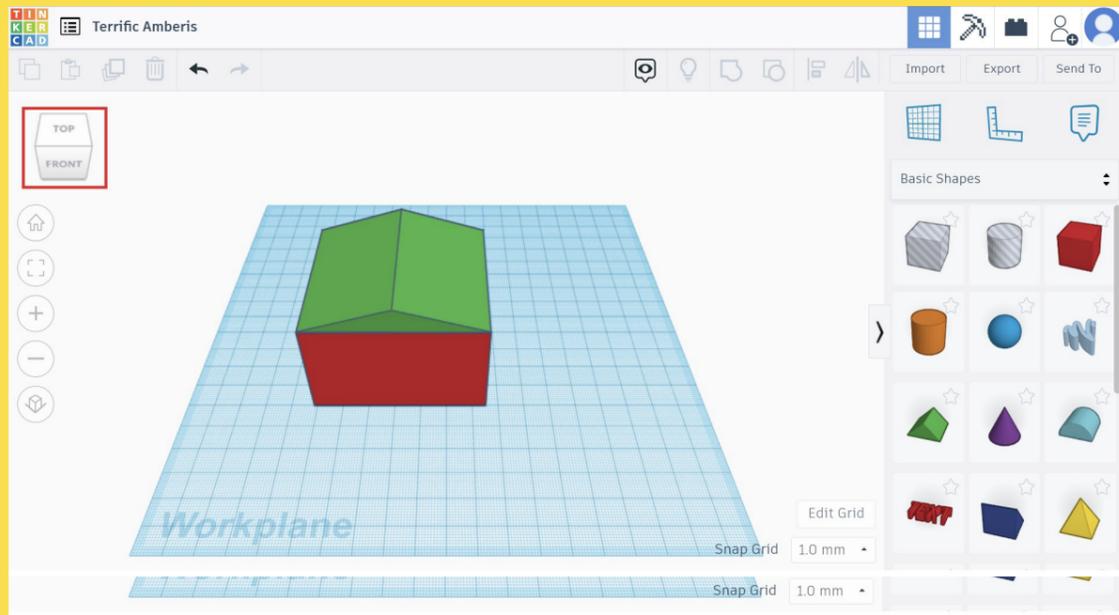
10. You can add multiple shapes by selecting them from the inventory.



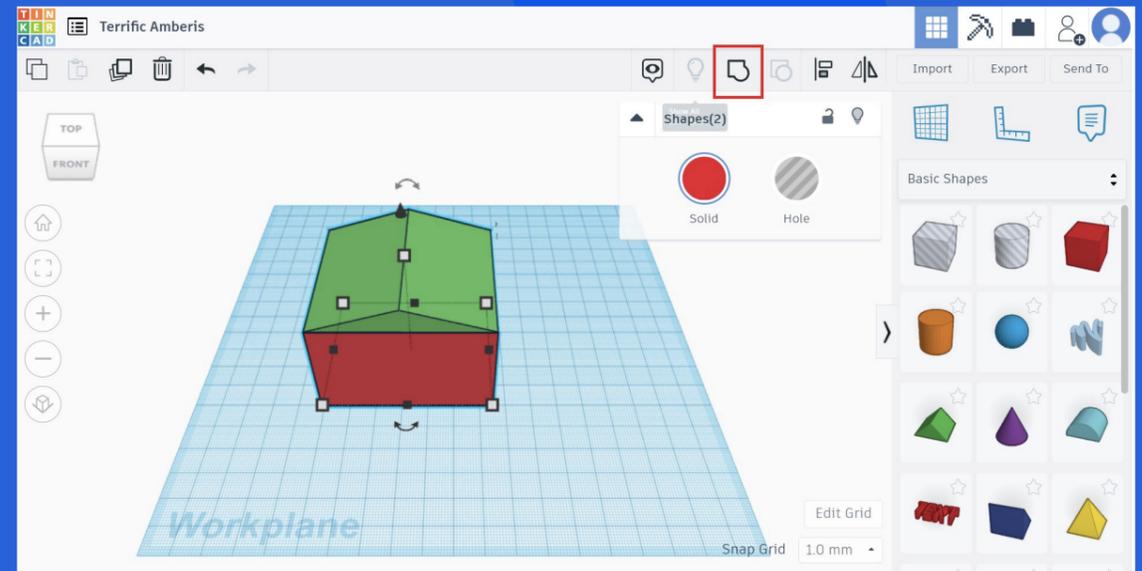
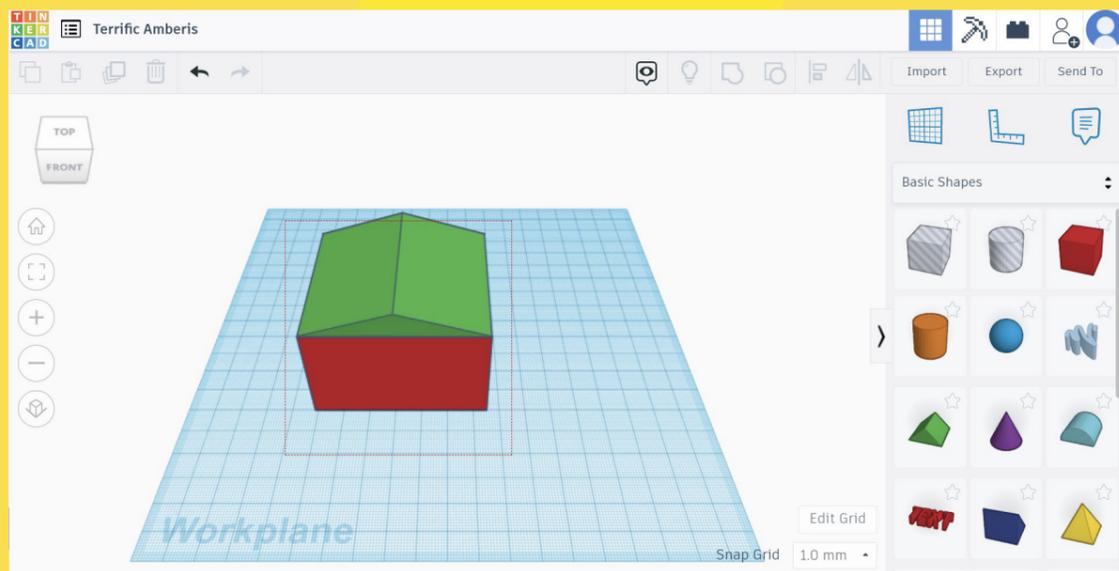
11. Click on the black arrow on top of the shapes to lift them up.



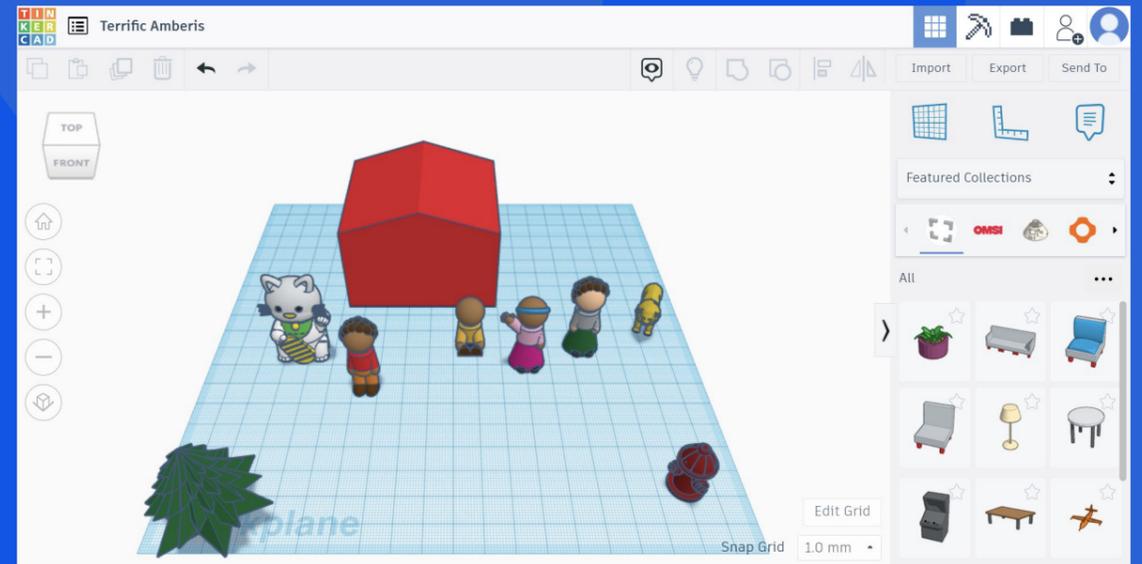
12. Move the Green colored roof and place it on top of the red colored box to make a house! Use the different views to make your job easier.



13. To join both the shapes together, click the left mouse button and drag a window around the two shapes. Then click on the group icon or hit Ctrl+G. You will see the colour of the two shapes change to a single color once they are joined together!



14. Go ahead and explore more. Add fun shapes from the inventory to create your design.



Here is a list of comprehensive [Tinkercad tutorials](#) to help you if you face any challenges.

ACTIVITY
DIGITAL SCHOOL

Are you excited to design more 3D models now?

We sure hope so!

In this activity, let us try to create a simplified 3D model of your school campus. Include different shapes, join them together, break them apart! Include characters, trees, and other structures, and let's see who can create a more life-like model, which is your school!



ACTIVITY

NOTES

A series of horizontal dotted lines for taking notes.





Lesson 5
**Setting
up XR**

01. OVERVIEW

In this last section, you will have a chance to put into practice all the skills which you have learnt in the subject – fundamental concepts of XR, identifying problems, creating markers, designing digital layers, and more to create your own XR setup. At the end of this section, you will have a fair understanding of creating a basic XR project.

1.1. Learning Objectives

At the end of this unit, you will be able to create a basic XR setup.

02. CREATE AN XR SETUP

Welcome to the last section of this course on extended reality. During this course, we have familiarized ourselves with the idea of extended reality and its benefits. We have also accumulated a few skills on the way to help us create an AR experience – how to apply design thinking, how to create QR codes, and how to create 2D and 3D graphics.

It is time that we put all that into practice and create our very own AR setup! Are you ready? Let's go!

ACTIVITY

In this activity, we are going to create a drawing in the real world, create a digital layer, and then set up our AR system with a secret message for the user. This activity is divided into 5 levels.

Things you will need:



Pen or pencil



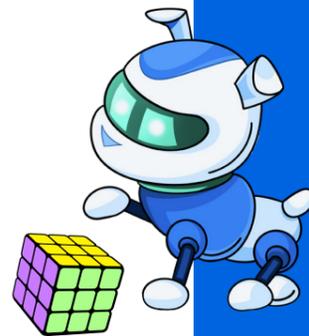
Computer with internet access



Smartphone (iOS or Android)



Drawing material (markers/crayons)



LEVEL 1 - AR DESIGN

1 YOUR NAME

2 NAME OF AR EXPERIENCE

Augmented Reality is a mix of the real world and computer images

This is an Oak Tree

It's a digital layer your can make visible through, for instance, your smartphone

3 REAL WORLD DRAWING

4 DIGITAL LAYER

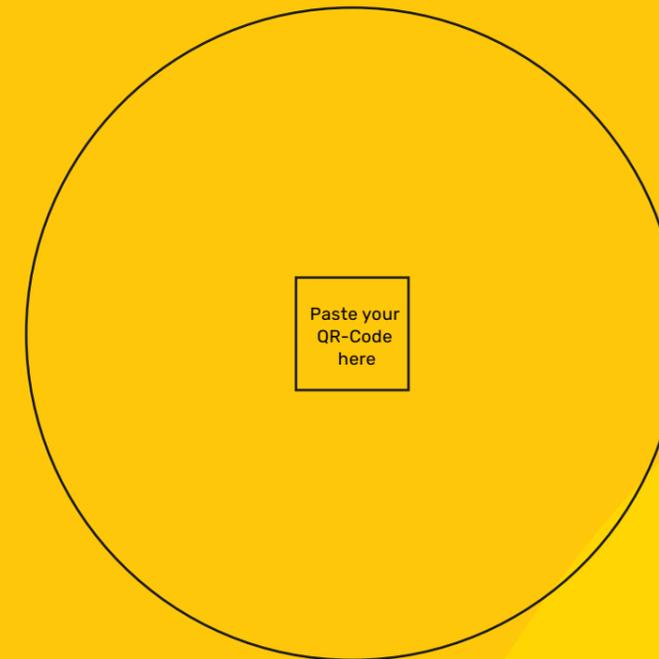
Drawing Video
 Photo Audio

5 SECRET MESSAGE

In level 1, you will use the augmented reality design prompts to design your own AR experience. You need to apply design thinking and come up with an idea for your AR project. Once you are ready, start responding to the design prompts. See the sample responses to the prompt below.

THEME:	Education
YOUR NAME:	Jonne Donne
NAME OF AR EXPERIENCE:	Secrets of our universe
REAL WORLD DRAWING:	Drawing of the solar system
DIGITAL WORLD DRAWING:	Drawing
SECRET MESSAGE:	The Solar System is the gravitationally bound system of the Sun and the objects that orbit it. Of the bodies that orbit the Sun directly, the largest are the four gas and ice giants and the four terrestrial planets, followed by an unknown number of dwarf planets and innumerable small Solar System bodies.

LEVEL 2 - MAKE A REAL-WORLD DRAWING

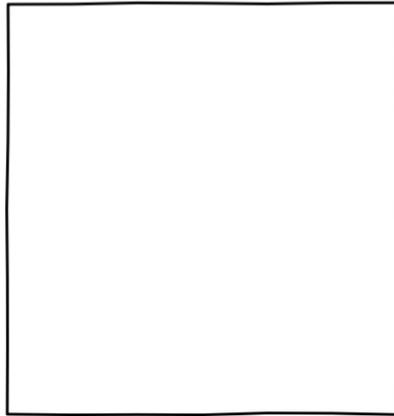


In this level, you will make a real-world drawing. This drawing will be scanned with your phone to start the AR experience with the help of a QR code that will go in the centre of your drawing.

See the sample real world drawing below.



LEVEL 3 - CREATING A DIGITAL LAYER



In this level, you will create the digital layer and add a secret message to this layer. You need to draw the digital layer on paper for this activity, but you can also use images, videos, and other graphics as your digital layer. See the sample digital layer below.



Secret message

The Solar System is the gravitationally bound system of the Sun and the objects that orbit it. Of the bodies that orbit the Sun directly, the largest are the four gas and ice giants and the four terrestrial planets, followed by an unknown number of dwarf planets and innumerable small Solar System bodies.

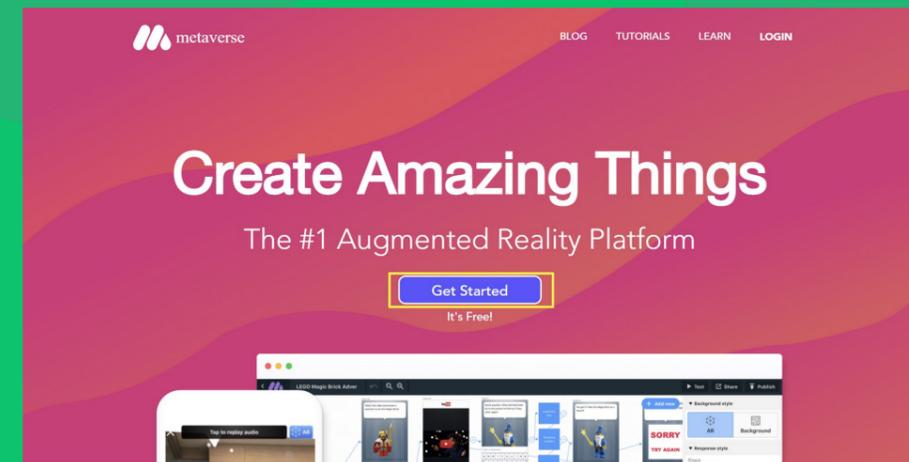
LEVEL 4 - BUILD YOUR AR EXPERIENCE.

In this level, you will use the Metaverse platform to build your AR experience. You will need to create an account on the metaverse platform at this level. You have to be at least 13 years old to create an account here. Ask your parents or teachers to create an account for you if you are not 13 years old yet.

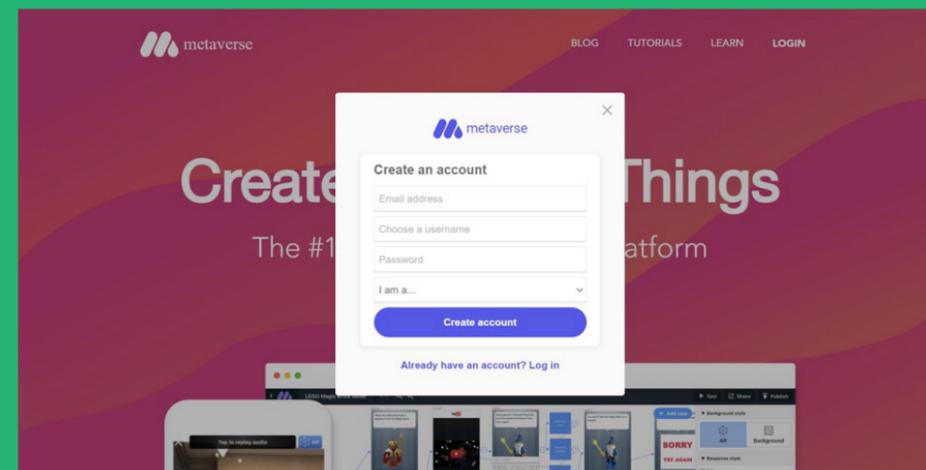
1. Go to [Metaverse Studio](#).



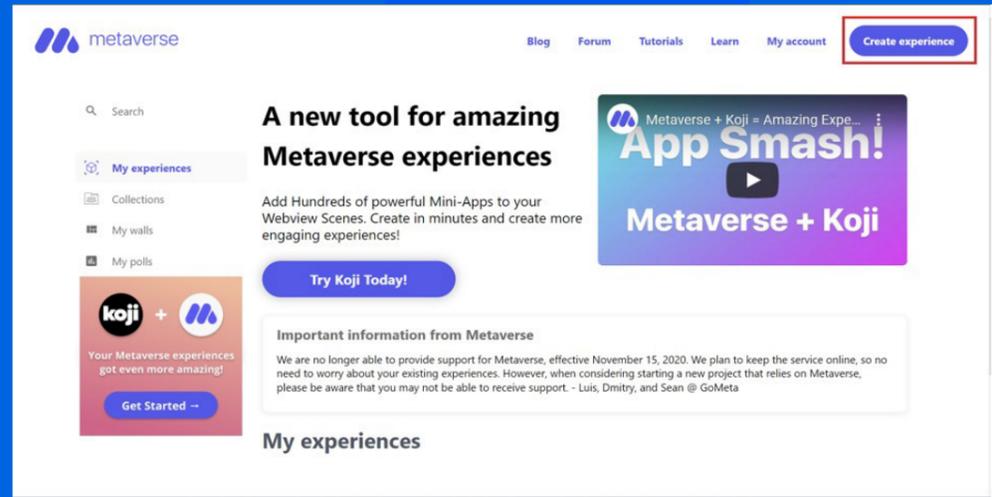
2. Click on 'Get Started'.



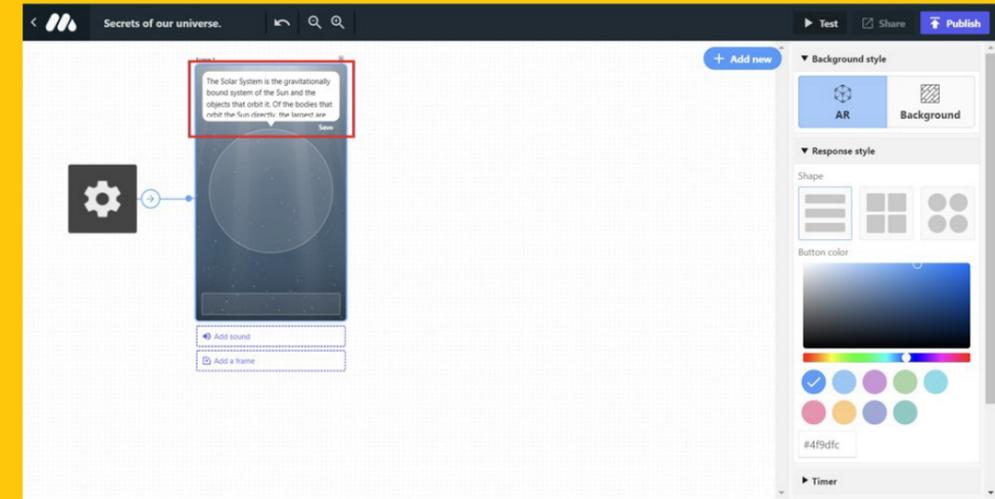
3. Enter an Email address, choose a username, set a strong password, and choose a role - 'Student' - to register.



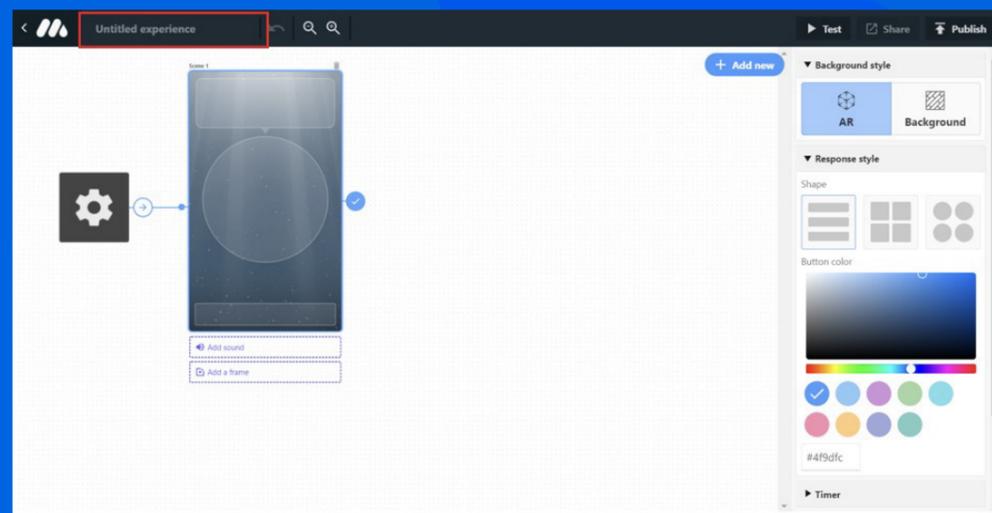
4. Click on 'Create Experience' to start building your AR app.



7. Add the secret message, by clicking on the box. Type your message and hit 'Save' once you are done.



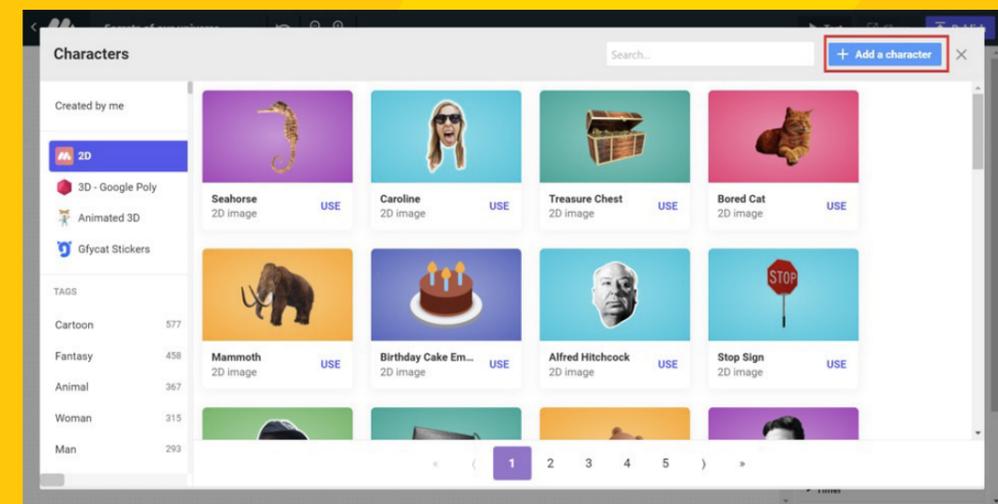
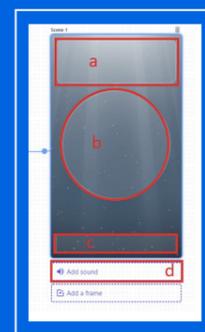
5. This is where you will create your AR app. Name your project from your AR design sheet.



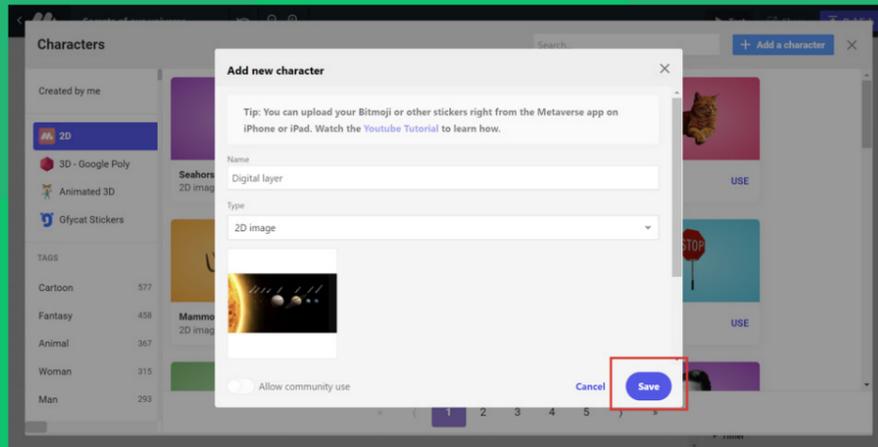
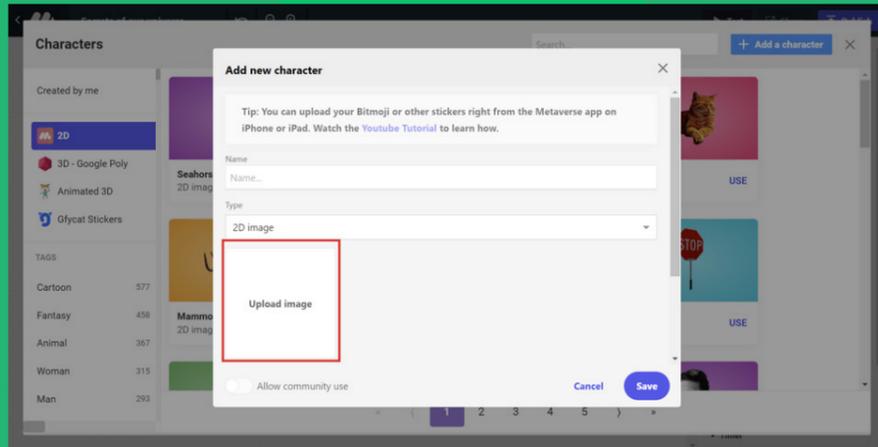
8. Add your digital layer drawing by clicking on the circle. You can click a photo of your digital drawing and add it here. (Remember our discussion on converting physical to digital?)
a. Click on 'Add a character'

6. There are different widgets present in the Scene 1 template available in our workspace.

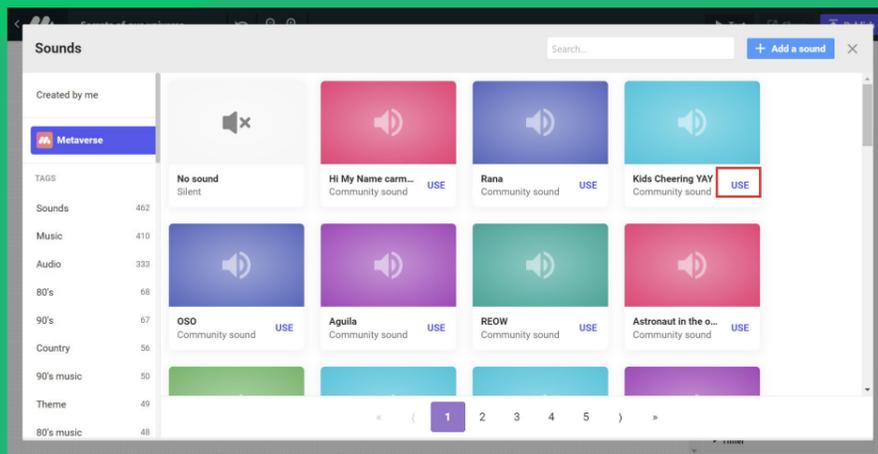
- a. This is where we will add our secret message.
- b. This is where we will add our digital layer.
- c. This is a button. We will not be using it in this project.
- d. We can use this to add a sound to our project.



b. Click on 'Upload image'. You can even name the image. Then click 'Save'



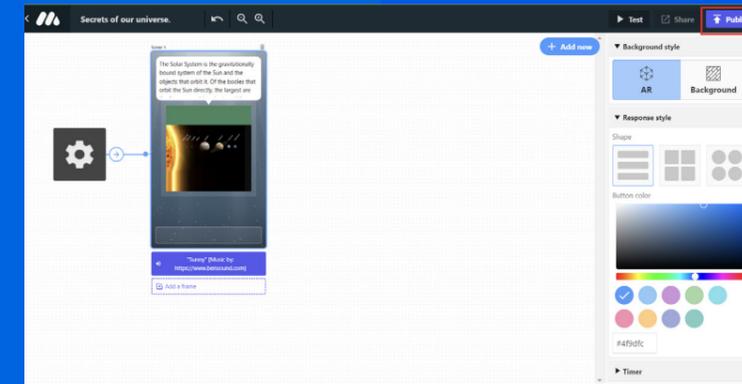
9. Add a sound to your app by clicking on 'Add sound'. Click 'Use' to select any sound.



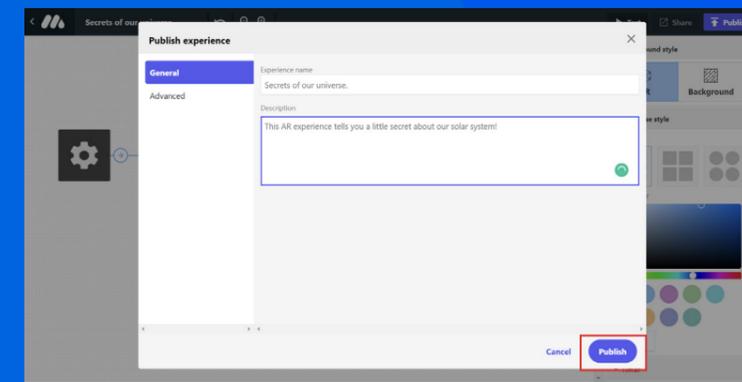
LEVEL 5 - PUBLISH AND USE YOUR EXPERIENCE

In this level, you will finalise and publish your experience. Then, we will try to use our experience using the metaverse mobile app!

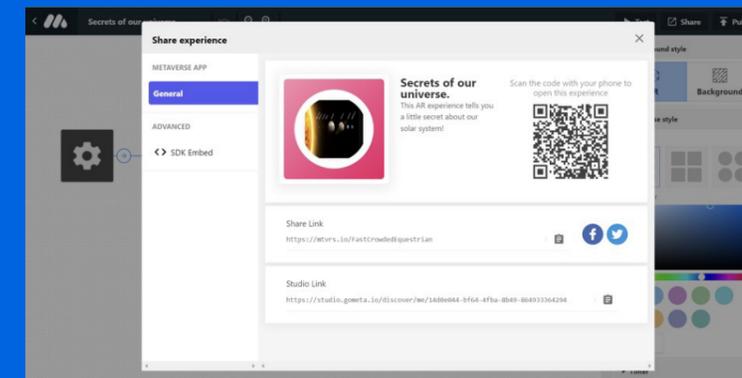
1. Click on 'Publish' on your AR experience screen.



2. Put in a description for your AR experience and click 'Publish'.



3. Our AR setup is ready to be used now! You can enjoy your own AR experience either by sharing the direct link or by using the QR code. We are going to use the QR code.



4. Take a print out of the QR code and paste it in the centre of your real-world drawing.



5. Install the Metaverse app on your mobile phone from here:

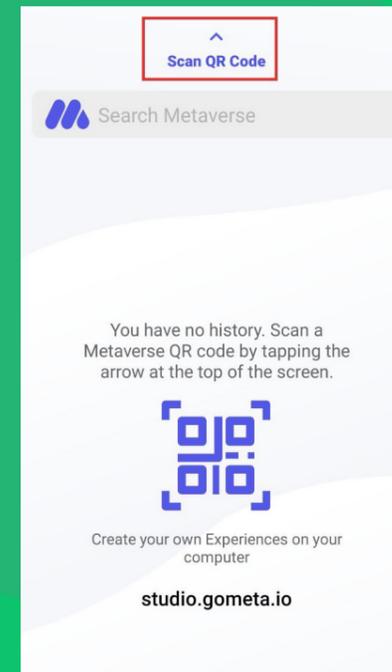
a. For iOS - [Metaverse - Experience Browser on the App Store](#)



b. For Android - [Metaverse - Augmented Reality - Apps on Google Play](#)



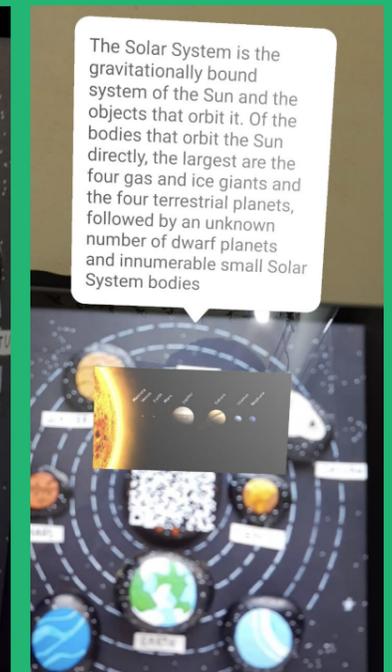
6. Open the metaverse app and click on 'Scan QR Code'



7. Point the camera to the real-world image.



8. Enjoy the AR experience!



Isn't that super cool!? Congratulations on making your first XR experience! Well done.

We have just given you a glimpse of the possibilities with XR. Spend some time on the platform to explore how you can expand your AR experience. Add more scenes, experiment with 3D models and buttons, and become a part of the digital universe.





NOTES

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NOTES

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Level 2

Bibliography



Level 2 | **AR/VR** | Student Handbook

Curriculum developed by teachers and academic advisors,
managed by 1M1B and supported by Meta Platforms Inc.