

Engaging children with STEM using Minecraft

A practitioner guide for engaging children with Science, Technology, Engineering and Maths using the popular construction-based computer game Minecraft

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Introduction

This guide is aimed at practitioners who are aiming to engage children with Science, Technology, Engineering and Maths (STEM), and considering use of the popular, construction-based computer game Minecraft.

Minecraft is available in a number of formats; the one used depends on specific requirements, including hardware. A separate guide to editions of Minecraft (2021) for engagement practitioners is also available, and includes potential alternative computer games should Minecraft not be a viable option.

Therefore, this guide does not address the individual editions of Minecraft available, or specific features that can be accessed. Instead, it focuses on the application of the game in a STEM engagement context, and aspects to consider when planning an activity, which are broadly relevant regardless of the edition used (and to some extent, whether alternative block-building games to Minecraft are used). It does not cover all eventualities, which should be considered in the context of specific projects.

The authors are not affiliated with Minecraft, and this not an official Minecraft resource. This guide is based on experience gained over several years of running and working on the successful [Science Hunters](#) programme of activities, which has been engaging children with STEM using Minecraft across a range of projects and fields since 2014, and was produced as part of its [Building to Break Barriers](#) project. More information about Science Hunters and Building to Break Barriers is available at the end of this guide.



Minecraft

Minecraft is an open-world, exploratory and generative video game¹, which after release in 2011 quickly became one of the most popular computer games in history. Players move around freely, building with and breaking a wide range of blocks with a variety of properties, and can explore different settings.

The game can be used in different modes (see overleaf) on a range of hardware. Players can play individually in single virtual worlds, or collaboratively in shared worlds on secure servers. Use of typed commands supports practise of basic coding skills. Some versions support 'mods' (modifications); third-party code that adds new or custom gameplay features to the base game. In some cases, content can be transferred between versions. Purchasing options vary between institutions and geographical locations, and should be checked locally.

Why use Minecraft?

Minecraft is ideal for communicating various concepts; it has features corresponding to real-world processes and relevance to natural and physical sciences¹⁻³ and is now used around the world as an educational and engagement tool⁴.

In the UK, 69% of 6-10 year olds and 81% of 11-14 year olds play video games⁵. The familiarity of the game and extensive experience that many children have with it can interest them in topics that they might not otherwise engage with and give them a sense of expertise and ownership^{3,6}.

Minecraft can particularly appeal to children with additional needs due to the nature of its virtual environment and facilitation of meaningful construction⁷. Playing together within this shared special interest, in an accepting environment, can have positive impacts on their social communication skills and wellbeing^{8,9}.

The game can thus be used to provide opportunities for scaffolding learning, employing collaborative learning approaches^{10,11} and supporting children to construct meaning together through dialogue during learning and play¹².

Science Hunters uses Minecraft to engage children with (STEM) for three key reasons:

- It is very popular – even referred to as one of the most important games of the current generation¹ – so is familiar and appealing to children, and can interest them in topics that might not otherwise appeal to them⁶. It is also relatively easy to use, and quickly picked up.
- Various features which represent real-world items and processes make Minecraft ideal for communicating about, and building understanding of, a range of scientific concepts³.
- The game can be used in different modes on a range of hardware, including Creative mode, which has high flexibility.

Further information: Detailed descriptions of Minecraft's features and its use in educational settings can be found in works by Nebel et al. (2016)⁴ and Lane and Yi (2017)¹.

Making STEM accessible

Why make STEM accessible?

Many groups of people are under-represented in STEM, across engagement and informal learning, formal study and the workplace, and may experience difficulties with retention and progression once in STEM roles. We know, for example that only 20% of A level Physics students are girls¹³, only 12% of engineers are female¹⁴ and 8% from Black, Asian and Minority Ethnicity backgrounds¹⁴, and furthermore women are highly under-represented in senior STEM roles¹⁵. Black children and children from lower socioeconomic status backgrounds are less likely to have science capital* and go on to STEM study and work¹⁶ and students from Black and minority ethnic backgrounds are less likely to progress to science roles post-graduation than their white peers¹⁵. People from low income, minority ethnicity communities can perceive science centres as ‘not for them’¹⁷ and girls can perceive STEM as ‘not for people like me’¹³.

These are just some examples; supporting people from a diverse range of backgrounds and circumstances to feel that STEM is ‘for them’ is important both for individual benefit and for wider society. Science is inherent in our everyday lives through our understanding of the world. A scientifically literate, engaged population and diverse STEM workforce means that talent is less likely to go untapped, progress is informed by a wider range of experiences and members of the public can more easily engage in dialogue around science^{15,16,18}. A notable example of the importance of such engagement has been public understanding of infection transmission and vaccination roles during the COVID-19 pandemic.

*Science capital: science-related qualifications, interest, literacy and social contacts¹⁹. Further information: [Science capital YouTube video](#).

Things to consider

- Computer games are very popular, but are not for everyone. For example, some might get motion sickness, and others simply don't enjoy them.
- Providing alternative activities can be useful for those who don't want to play the game – and for any groups waiting to play.
- Include flexibility in designs where possible – this makes them adjustable for a range of needs, abilities, situations and unexpected events.
- Digital accessibility can be low in some settings and communities. Do the people you're working with have access to hardware and Minecraft licences, and know how to operate the game? Can you provide resources and assistance, temporarily or longer-term? How could this be funded and supported?

It's not just about Minecraft

While Minecraft acts as a hook for children's interest and attention, and contains many features making it an effective science communication tool, engagement can be enhanced by adding other features alongside playing in the game.

Looking at, handling or otherwise exploring related resources can add a practical, hands-on element to activities, and provide a reference point or 'anchor' for participants that connects the virtual (Minecraft) to the real world.

Practical elements can include, for example, using items such as microscopes or robots, handling or observing related samples or models, solving puzzles, playing games, trying or observing experiments or paper-based designs.

Images of real-life features of the topic can be useful resources, as can videos if they add value to the explanation of the topic, for example, demonstrating processes or attention-catching events.

These practical elements can be used as a baseline on which to build participants' knowledge, then lead onto allowing them to construct their own meaning through exploration and building in Minecraft. This approach has been shown to increase subject knowledge and understanding²⁰.



Science Hunters sessions are all slightly different, and are adaptable to the needs of those taking part.

However, they have some core elements:

- A **hands-on, interactive topic introduction**. This usually involves using some physical resources and discussing them.
- For example, during the 'Coral Reef Conservation' session²¹, some examples of coral are shown, along with images of threats to coral health such as illegal fishing vessels.
- A **Minecraft building or exploration task**. These are differentiated for age, ability, and experience with Minecraft and can be stepped.
- For example, in the 'Corals' session, children explore a pre-built coral reef, build their own coral reef, build a glass-bottomed observation boat, or devise their own related build.
- This building is **child-led**. Sessions follow a **constructivist** pedagogy utilising anchored instruction and constructionism to scaffold learning^{3,6}.

The modes of Minecraft

The two key modes of Minecraft are 'Survival' and 'Creative'. Three other modes, 'Adventure', 'Hardcore' and 'Spectator', are modifications of the two key modes.

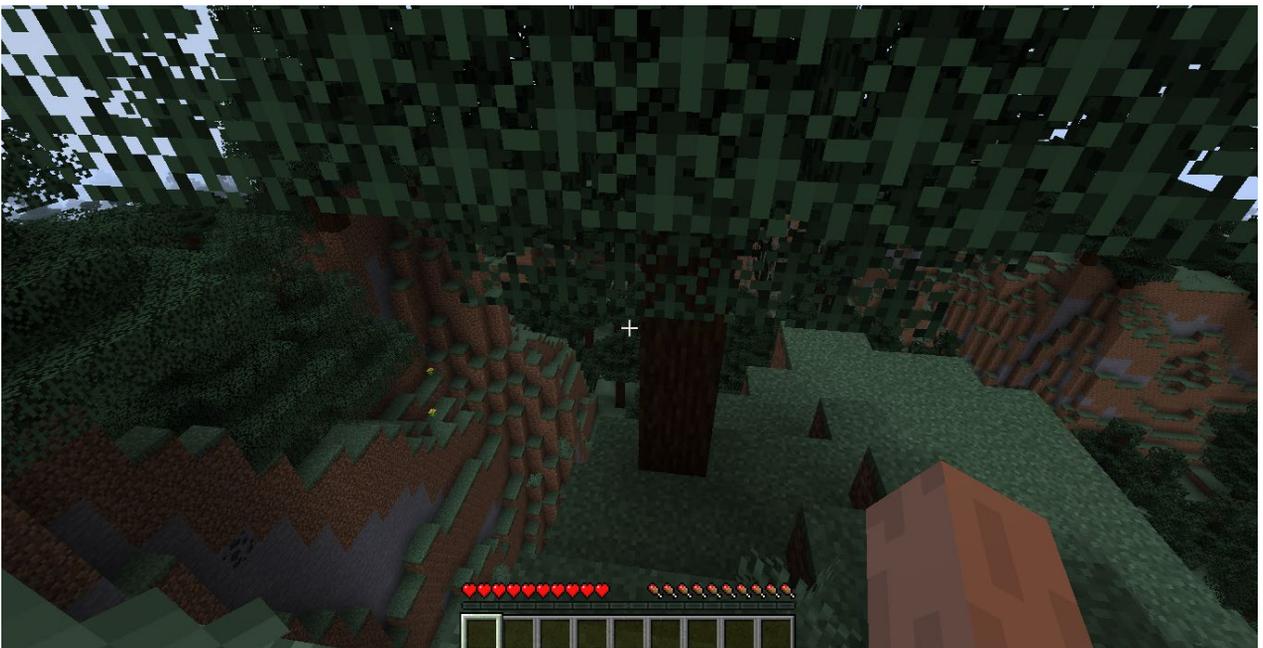
Survival mode

Players collect resources, fight off hostile mobile entities ('mobs'), build and eat. Items, collected in an inventory to increase availability, are finite resources. Only encountered items can be gathered, with certain blocks found in specific settings. Item availability decreases (running out unless replaced) as items are used. 'Crafting' processes create other items and tools with existing resources.

'Health' and 'hunger' bars impact progress. Hunger points replenish as food is eaten. At low hunger points certain abilities are lost and at zero hunger points the health bar depletes. Health regenerates as hunger points increase again.

Environmental features and mobs can damage players, depleting the health bar. At zero health points, players 'die'. They can respawn, but lose collected items. At 'Peaceful' difficulty level harmful entities are disabled and hunger and health bars replenish automatically (other levels are 'Easy', 'Normal' and 'Hard').

From a STEM perspective, Survival mode can be useful for exploring concepts such as physiological responses to stressors such as lack of water, shelter and food, sustainability and consumption under conditions with finite resources and impacts of environmental conditions.



Minecraft in Survival mode: the row of squares at the bottom of the image is the hotbar, where players place items they are currently using. The health (hearts) and hunger (drumsticks) bars are visible above the hotbar.

Creative mode

Creative mode removes 'survival' aspects. Players have unlimited numbers of inventory blocks with no need to search for or gather them, saving time.

Items do not deplete or run out, no health or hunger bars affect progress and players are not damaged (they can still 'die' and respawn in specific circumstances).



Minecraft in Creative mode: there are unlimited resources in the inventory, and no health or hunger bars.

Creative mode has the greatest scope for building and players can focus on construction rather than managing resources.

Command blocks, structure blocks and spawn eggs are available in Creative mode (not available in Survival):

- **Command blocks:** execute certain actions, e.g. teleporting the player to another location. Must be correctly set up; these can offer introduction to coding.
- **Structure blocks:** used to copy and recreate a previous build (i.e. make a template).
- **Spawn eggs:** instantly create creatures, e.g. cows and pigs.

Spectator mode: players can explore a world, always flying, but cannot interact with it or the inventory. They can view the world from the perspective of other entities within it, but are invisible to other players in a different mode in shared worlds. Players can go through blocks and other entities, and are not damaged except in very specific circumstances. Can be useful for educators to observe student progress and activity.

Adventure mode: preserves pre-built maps; player ability to place/break blocks is restricted so that the world can't be modified as it would in Creative or Survival. Otherwise similar to Survival as players must manage hunger and can interact with other entities and be damaged/killed. Useful to allow players to explore and interact when a map must stay intact.

Hardcore mode: Survival mode with difficulty level always set to 'Hard'. When a player dies either the map must be deleted, or in a shared world the player must then be in Spectator mode (they cannot respawn). Provides an extra challenge for more experienced players.

Further information: 'Utilising the various modes of Minecraft in teaching'²².

Single- and multi-player use

Minecraft can be used as a single-player game on individual devices, by a single player or by players working in pairs or small groups. There is no in-game communication between players on different devices, and the worlds are completely separate.

As a multi-player game, Minecraft is played on an online server which is a shared space in which players build together and can communicate by messages. An online server is required, which can be kept private.

There are advantages and disadvantages to both options, and which is used will depend on specific circumstances, resources and requirements:

	Single-player	Multi-player (shared server)
Advantages	<ul style="list-style-type: none">• Prevents issues occurring between players (destruction of builds, disruptive messages)• Can aid focus• No requirement for shared online server• Collaborative play possible through paired working• Video calls or similar can be used for playing concurrently if internet and equipment available	<ul style="list-style-type: none">• Groups can play together in same world• Can communicate in-game• Complete projects together, possibly more quickly• Collaborative play• Builds remain on server• Players can be 'together' from different locations
Disadvantages	<ul style="list-style-type: none">• Fewer opportunities for collaborative learning• Players are all in separate worlds and cannot communicate in-game• Builds remain on individual devices	<ul style="list-style-type: none">• Potential for disruption between players• Requires dedicated server• Requires online connection throughout

Cheats

'Cheats' (enabled in game settings) allow players to set weather, daylight and new spawn points. This is useful for e.g. creating certain weather conditions, keeping the world in daylight and setting players to respawn near their building area. Players can also switch between modes and play in one mode on a map created in another mode. Specific cheat codes can be found by online searching.

To pre-build or not to pre-build

The virtual worlds used for Minecraft engagement can be presented in a variety of ways, including:

- a completely random world, that children build within;
- a world set to present a specific environment using a 'seed code' (see box below), that children build within;
- a world that has been pre-built for the purpose of the activity, which children can either build within, or explore (or both).

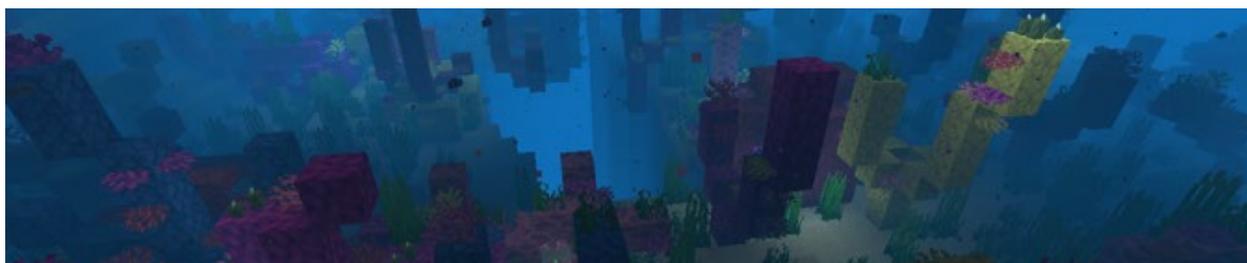
'Seed codes' are codes that Minecraft uses to construct a particular world for you. These codes can be found by searching online. You could search for the environment you want to be in, or a feature such as a village, for the version of Minecraft that you are using; the most straightforward way is to enter relevant search terms, such as 'Minecraft 1.17 seed tundra', into a search engine.

It's important to remember that seed codes are specific to Minecraft versions, so for example, a code that works in Minecraft Java version 1.14 might not work in version 1.16.

When you have the seed, which is usually a sequence of numbers, you need to enter it whilst creating a new world. In the standard version of Minecraft, you can do this by selecting 'More world options' in the 'Create new world' panel, then entering the seed code under 'Seed for the world generator'.

Topics can also be designed to cover a range of world design options. For example, the Science Hunters coral reef session can be delivered using:

- A randomly-generated world in which the first task is to navigate to a coastal area, before completing challenges such as building a research observatory;
- A suitable environment generated using a seed code, in which children can complete the challenges;
- A pre-built world containing a coral reef with a range of features and information. Within this world, they can either complete challenges as they would without pre-built content, or fly around the world to explore its content.



These variations provide a range of options to take into account different levels of experience, ages, abilities, pre-existing knowledge and time and resources available.

Further information: 'Utilising the various modes of Minecraft in teaching'²².

The most suitable option will vary between settings, logistics and audience, and also the nature of the topic and tasks set in Minecraft.

For example, during the Science Hunters 'volcanoes' topic, children can be tasked with mixing lava and water, and building a volcano, which do not need a specific environment. They are often presented with randomly generated worlds, which also have the advantage of producing variation within the group.

However, there are circumstances in which a partially prescribed world is beneficial. If time is short, or participants are younger or inexperienced players, it can be useful to provide them with a world, already loaded, that contains a suitable environment to demonstrate desired concepts and with relevant blocks placed into the hotbar ready for use.

In the case of the 'volcanoes' topic, this can be a hill with a village at the bottom and ready-placed lava and water blocks in the hotbar.



This enables participants to experiment with the effects of a lava flow on the settlement, without first having to build structures, and immediately focus on using the relevant items.

Features such as a beacon to enable them to find their way back to the site if they move away from it can also be included.

Further information: 'Utilising the various modes of Minecraft in teaching'²².

Face-to-face and remote engagement

Whether activities are delivered face-to-face or virtually depends on a number of factors and specific circumstances, and only one option may be viable in a given situation.

Face-to-face delivery is often seen as preferable to virtual delivery. It certainly allows more direct interaction between deliverers and participants, and can have social-communication benefits^{8,9}. Being physically present can remove factors such as the level of involvement needed from external staff, for example teachers, and for participants or their organisations to provide hardware and software. Remote learning at home is also known to be difficult for some groups²³. However, virtual delivery also carries advantages, such as allowing delivery to continue during restrictions, reducing travel-related costs and climate impacts, and widening geographical reach. With careful planning it can be as well-received as working in-person²⁴ and is also preferred by some people²⁵, better meeting their needs than face-to-face delivery. Decisions around delivery type are individual and specific and the mode chosen will depend on logistical, audience and practical needs.

Whether deciding between options, or preparing for pre-determined mode of delivery, there are some considerations that can be addressed prior to activities to facilitate smooth running of activities. These include:

Face-to-face delivery

- **Who** will be leading and delivering the activity?
- Is the **location** internal or external to you?
 - If external, who else will be needed to support?
 - What information will they need?
- **Where** will it take place?
- Will participants be attending from **separate sources** or as a part of an **existing group**, e.g. a school or community group?
- Is the location **accessible** to your audience?
- Is anything else happening at the **same time** that could affect your delivery?
- Is the **timing** of your activity suitable for your audience?
- Are **computers** already in place or will they need to be provided?
- How will you get there, and **transport** any equipment needed?
- How will equipment be **secured**?
- **How will people get information** about your activity and how to take part?
- Do you need **timed** and/or **pre-booked sessions**?
- Are you likely to have long **queues**?
 - Can you provide **activities** to do while participants wait?
- How will you collect **evaluation data**?

Virtual delivery

- **Who** will deliver the activity remotely?
- Will participants join **separately** from their own locations, or **together** from the same physical place?
- Will participants be attending from **separate sources** or as a part of an **existing group**, e.g. a school or community group?
- **How will people get information** about your activity and how to take part?
- **How will they join** you remotely?
- Will you need **individual contact details** to enable participation and how will these be **stored securely**?
- Is the format **accessible** for your audience?
- For participants **joining separately**, **who will be supervising** them at their locations?
- For participants **joining from the same place**, **who will be supervising** them in the room?
- Are there likely to be issues with **digital access**? How could you mitigate those?
- Will you **deliver content**:
 - Live?
 - Pre-recorded?
 - A blend of the two?
- What **backup plans** can you have in place for internet or other technical difficulties, for example providing content to be used in the case of lost connection?
- Those supervising (e.g. teachers in schools) will need to be **actively involved** in helping with delivery:
 - how can you help them to **prepare** for this and support on the day, for example remaining online to **assist** with the practical element after delivering live content?
 - holding **preparatory meetings** and **sending resources** in advance may be useful²³
- Will they have **access to hardware and software**? If not, could you provide this?
- Are **other resources** needed to support the activity?
 - How will people get these?
 - Will they have to use resources to access them, e.g. printing and is this **feasible**?
- How will you collect **evaluation data**?



See 'Moving dialogue online'²⁶ for information on live platform options.

Some planning considerations

- Is Minecraft a **viable option**? You may need to consider:
 - **Costs** (licences, hardware, accessories such as keyboards, etc.)
 - **Hardware** available
 - **Number** and **type** of **licences** needed
 - Supporting **software** and **accounts** for licences
 - Use (or not) of a Minecraft **server**



- Who is your **audience**?
 - What is needed to ensure that they can **access** the activity?
 - How easily can they **use the game**?
 - What level do you need to **pitch** the activity at? Is it **flexible**?
 - Do they have sensory or physical, or other, **access requirements**?
 - Do they have **access to the game** or will you need to provide it?



- Are you likely to need a **pre-built world**?
 - If so, **who** will create this?
 - What are the **costs** (for example, staff time, payment)?
 - Will you make this **available to other people**, and if so, how?

- What **mode** of the game will you use? Will you run a **single- or multi-player** game?

- What **accompanying resources** might you need?
 - How easy are these to **create or obtain**?
 - What are the **costs** involved?



Some planning considerations (continued)

- **Where** will the activity take place?
 - **Locations** might include schools, public settings, home-based activities
 - How much **space** will be needed? Are there **specific requirements**?
 - Will you use **in-person or virtual** engagement?
 - Is **internet access** needed?
 - If using remote delivery, is this **available** and **stable**?



- **What format** will your activity take?
 - For example, will it be delivered **face-to-face, live online, or via pre-recorded** content?
 - Will you produce any **materials** to go with the activity, such as fact sheets, videos or instructions for running a session again?
 - Will you need **worksheets and activities** to run parallel to Minecraft elements, e.g. for split groups?
 - How will people **access** supplementary materials?
 - Who will be **supervising** the children, and their use of hardware and software?
 - What staff **training** and **checks** are needed?
 - What needs to be covered in a **risk assessment**?



- How will you **evaluate** your activity?
 - Evaluation should be built into activity design **from the outset**, rather than retrospectively or as an afterthought
 - **Data collection** should be balanced with participant **enjoyment** and experience
 - Where will you **disseminate** your findings?
 - Do you need **ethical approval** for your data collection?
 - Consider using existing guides and approaches, e.g. from the University of Manchester²⁷ and Arts Council England Generic Learning Outcomes²⁸.



Science Hunters

Science Hunters is an outreach, research and Widening Participation programme initiated in 2014 at Lancaster University. Through a bespoke approach using a defined pedagogy, various Science Hunters projects have engaged around 20,000 children, mainly those who may experience barriers to accessing educational opportunities, with Science, Technology, Engineering and Maths through Minecraft. Projects reach across the UK and have reported benefits for participants (please see references 3, 6, 7, 17, 18 and 22 for further information).

The programme is now based at [UWE Bristol](https://www.uwe.ac.uk) and [Lancaster University](https://www.lancaster.ac.uk). For more information, please contact sciencehunters@lancaster.ac.uk or sciencehunters@uwe.ac.uk. The input of all those who have contributed to and supported previous work is gratefully acknowledged.

Building to Break Barriers



Suspension bridge built by Alex Kiyani

Building to Break Barriers uses Minecraft to engage children from under-represented groups with engineering. It is derived from the Science Hunters project, which supports children facing potential barriers to accessing educational opportunities, to engage with Science, Technology, Engineering and Maths.

Building to Break Barriers works with engineers, education and outreach practitioners and children and young people around the UK to co-produce and deliver Minecraft-based sessions about engineering. The project focuses on reaching children and young people from groups under-represented in engineering, increasing representation of engineers to enable children and young people to see 'people like them' in engineering roles, and offering a different view of engineering and the way it is used, outside of traditional perceptions.

Please see [Science Hunters](#) and [Building to Break Barriers](#) for more information about the projects, or email ExtendingSTEM@uwe.ac.uk.

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