**Article**

# Elements of construction – Minecraft and the Periodic Table

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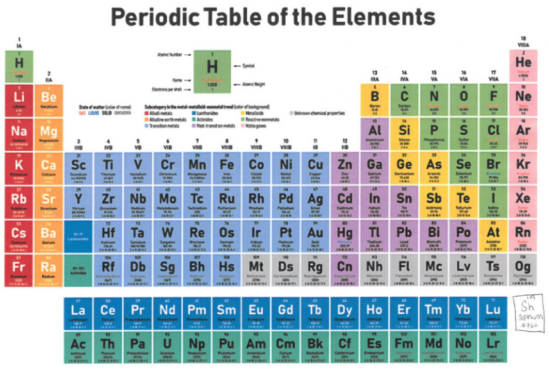
Minecraft is a popular computer game that allows the construction of almost limitless creations, and is used in learning contexts around the world. The widespread appeal and familiarity of the game makes it ideal for engaging children and young people with topics that might not otherwise interest them. With this in mind, the Science Hunters project, with support from a Royal Society of Chemistry (RSC) Outreach Fund grant, developed five Minecraft-based informal learning and engagement sessions about the periodic table, carbon, helium, uranium and gold, as part of the 2019 International Year of the Periodic Table (IYPT).

Minecraft is a construction-based, open-world game in which players can move freely and build items, placing and breaking blocks with a wide range of appearances and properties. Not only are the possibilities almost endless, but the game is extremely popular; it is the second-best selling game in the world (*1*). When asked, 95% of UK school students across all year groups had heard of it (*2*). It has been described as one of the most important games of the current generation (*3*).

There are many real-world analogies in Minecraft which, combined with its popularity, make it a great tool for communicating scientific concepts (*3-5*). Science Hunters, an outreach project based at the Science Communication Unit at UWE Bristol and Lancaster University's Environment Centre, uses Minecraft to engage children with science. Sessions take place in schools, at public events and in dedicated Minecraft Clubs for specific groups under-represented in science (*5-7*). Not only do participants greatly enjoy these sessions (*6*), they also increase their subject knowledge and understanding (*7*). Minecraft enables active construction of knowledge, interaction, and team working. It is simple, affordable, and accessible, making it viable for classroom use (*8*). Detailed descriptions of Minecraft and its application in a range of formal educational settings can be found elsewhere (*3, 8*).

## Engagement with chemistry and the IYPT

Results of the 'Public Attitudes to Chemistry' report (*9*) suggest that chemistry could benefit from communication through the novel use of media that children already enjoy and associate with leisure. Overall, public engagement with chemistry was reported as low, and the subject was commonly associated with lessons, chemicals and medicines. School was cited as putting off 25% of respondents. Therefore, to promote positive perceptions of chemistry in young people, in 2019 (IYPT), the RSC funded Science Hunters to create five Minecraft sessions about the periodic table and four selected elements, explained from an environmental science perspective. The sessions were developed for and delivered to the project's Minecraft Clubs for children with Special Educational Needs (Lancashire) and Looked After Children (Cumbria and Worcestershire).




***The element 'Sophium' (Sh) as created by a Minecraft Club participant and added to the periodic table, during a 'Periodic Table' session.***

## Science Hunters 'elements' sessions

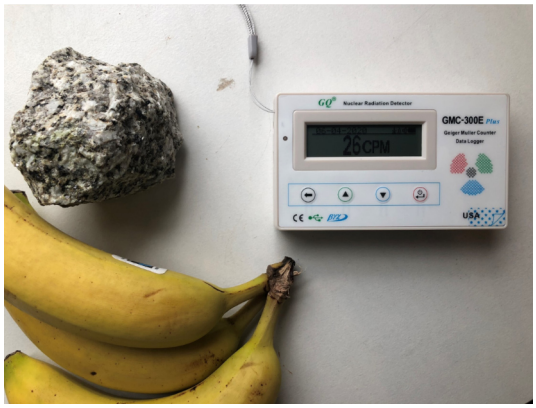
### The Periodic Table

In this session, the periodic table, how it is constructed, and basic atomic structure (protons, neutrons and electrons) are introduced visually using a small number of presentation slides. Participants are provided with small items to lay out the subatomic structure of a selected atom (for example, sweets can be used for this activity due to the variety of shapes and colours available) and then build atoms of other elements in

Minecraft, using the hands-on activity to plan if desired. Since elements with low atomic numbers are simpler to build, these are suggested initially. Selected elements can be related to real-world uses to demonstrate the practical relevance of chemistry. Popular examples include hydrogen (space rocket fuel), helium (balloons), lithium (batteries) or beryllium (structural material for high-speed aircraft). Participants may wish to create their own elements as an extension activity. For example, children taking part in one of the Science Hunters clubs created an element named Sophium (after the session leader) and identified its use as 'making bananas explode'. They assigned it a symbol (Sh), atomic mass and atomic number, and added it to a copy of the periodic table.

**Uranium**

The properties of uranium, its discovery, radioactivity and 235U application in nuclear power generation through fission are introduced briefly through a slideshow. Common samples emitting low and safe levels of radiation, such as granite rock and bananas, are used alongside a Geiger counter to demonstrate radioactivity. In Minecraft, children are provided with a prebuilt map, made with the Minecraft modification ('mod') Big Reactors. They can complete the build of a nuclear reactor, mine 'Yellorium ore' (the Minecraft equivalent of uranium ore) from the quarry, then process it to make Yellorium ingots. These are then placed in the reactor to generate heat, creating steam which turns the turbines and then the generator, producing electricity.




***Geiger counter indicating low levels of radiation emitted by granite and bananas, used as a demonstration during the 'Uranium' session.***

**Helium**

The properties and uses of helium are introduced. Relevant examples are given, including cooling properties, as used in MRI machines and cryostats, and buoyancy, demonstrated with balloons. Where appropriate, links can be made with the uranium session to explain the difference between fission and fusion, and the gold session as cryostat plates are gold plated to provide shielding for sensitive samples from radiation. Images of the sun are used alongside an explanation of how nuclear fusion turns hydrogen into helium, releasing energy in the form of heat and light. The subsequent Minecraft challenge is to build an item that contains helium, using examples from the introduction. This could be party or weather balloons, or blimps; model MRI machines, particle accelerators or satellites; or the sun. There is also the option of building the chemical symbol as it is shown in the periodic table.

***A Cryostat, where liquid helium is used as a coolant and gold plating shields sensitive samples from radiation. Photo credits Andrew Guthrie.***

**Carbon**

Elemental carbon can be introduced including its symbol, atomic mass and atomic number. Samples of different forms of carbon are used to give physical examples that participants can hold, interact with and use. These include a diamond, graphite, and a sample of coal. Participants can even draw the carbon atom using the graphite samples. Global warming and its consequences are discussed in the context of anthropogenic carbon dioxide release from burning coal and other fossil fuels. The reason that carbon is often described as 'the element of life' is also explained alongside a video explaining carbon-based lifeforms. Images of the different forms of carbon and molecular modelling kits are distributed amongst participants to help them build a structure in Minecraft. To do this, they can either choose blocks to represent carbon atoms and bonds, or use forms of carbon that exist in Minecraft, such as building a structure out of diamond blocks or mining for diamonds.

**Gold**

A brief slideshow introduces the atomic structure, position in the periodic table, properties and uses of


***Figure 4. Diamond and graphene models using molecular modelling kits.***

gold. Key phrases such as 'transition metal', 'conductive', 'malleable', and 'corrosion' are explained within the discussion. Common uses, such as in jewellery and smartphones, are explained alongside physical examples for participants to examine. Lesser known uses, such as in dentistry, in equipment in laboratory experiments and as radiation protection in space, are included.

A 'Badlands' biome (known for containing plentiful gold) Minecraft world is set to survival mode, and participants are given the challenge of mining for gold. Extensions to the challenge based on interest and ability include using gold to build craft-powered rails to speed up mining and crafting different forms of gold (ores, nuggets, ingots and blocks). Participants are also free to build items related to any of the examples of uses of gold covered in the introduction.

## Evaluation

In order to gauge how engaging the sessions were, 44 participants were asked to indicate their level of interest in the topic both before and after the session, ranging from '0 – not at all interested' to '3 – very interested'. Changes in responses were analysed as a measure of engagement efficacy. Participants were aged between 7 and 13 years and attended Minecraft Clubs for under-represented groups. Attendees were invited to provide written feedback, the contents of which were also evaluated. Mean interest before taking part in a session was 1.9 ± 0.2 (63% on a scale of 0-3). After the sessions, mean interest was 2.3 ± 0.1 (77%), which was a statistically significant ($p < .001$) increase.

Qualitative feedback from children, parents and carers was assessed against Generic Learning Outcomes (*10*) and mainly indicated outcomes related to 'Knowledge and Understanding' (e.g. "they are all types of atoms", "O is Oxygen", "arsenic is highly poisonous", ""the periodic table is made up of different elements that make up the world e.g. gold (Au), carbon (C) and titanium (Ti)"). Additionally, comments revealed aspects related to 'Behaviour and Progression' ("I'm still learning and trying to understand"), 'Attitudes and Values' ("I really enjoyed the introduction and I found it interesting") and 'Enjoyment, Inspiration and Creativity' ("it is the best thing ever", "They really enjoyed the video and we even had tears of joy"). 'Evidence of Skills' (e.g. perseverance, cross-referencing information, handling materials) was recorded observationally.

Overall, the developed sessions presented an effective method for engaging children with chemistry. There is much scope for future development of resources utilising the Science Hunters approach and Minecraft's function and appeal to inspire younger generations about a subject that many are known to have less positive experiences with in school.

## Acknowledgements

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