# Is there enough space in the curriculum?

Jeremy P. Thomas

**Abstract**

The space sector is of huge value to the UK, which is a world leader in space research and applications. However, an examination of the current science curriculum for 5- to 16-year-olds, especially in England, shows a lack of opportunities to learn about space. This article gives an overview of the importance of space for the UK and reviews the current number of specific space topics in the National Curriculum and in GCSE specifications. Some suggestions are made for supporting easily embedded opportunities for all students to engage with space, initially in the GCSE science curriculum, based on evidence of its inspirational effect on learning and the significantly more positive effect that teachers can have on potential career pathways when compared with space outreach initiatives.

Space is frequently promoted as an inspiring topic for all ages, which encourages young people to study and follow careers in STEM subjects. There is plenty of informal survey evidence of interest in space (IPSOS, 2019) as well as children's engagement with space-themed books and toys (LEGO, 2019). Many teachers experience students' fascination with space and, historically, strong claims have been made about the effect of the Apollo missions on interest in STEM (Endeavor, 2019). This effect may not have been sustained in later generations, but current space programmes, such as those of SpaceX and Blue Origin, have rekindled public interest in the field as evidenced by the media coverage devoted to them. Space exploration today is no longer exclusively an academic pursuit, or an activity carried out by large space agencies, but a field where smaller organisations and companies participate, where space applications are an essential part of everyday life and where opportunities for employment abound. However, there is a mismatch between interest in space and ambition to pursue space-related careers, as shown clearly in the report on astronaut Tim Peake's 2015 Principia mission (Bennett *et al.*, 2018). This mismatch translates into a serious skills shortage, as will be discussed later, in an area of enormous importance to society and the UK economy, and yet the current National Curriculum specifies a very small number of specific space topics, while the most common GCSE exam specifications (ages 14–16) ignore them completely.

This article begins with evidence for the crucial importance of space to the UK economy, presents a review of space in the curriculum, mainly in England, and gives some initial ideas for using space as an inspiring theme to deliver other relevant parts of the curriculum. The ultimate aim suggested is to give teachers, particularly non-specialists, the opportunity to deliver well-resourced, space-themed learning in normal lessons. This would expose a more diverse range of students to the opportunities rather than just those able to participate in wrap-around activities provided by most existing programmes.

## Why is space important?

Apart from anecdotal evidence for the inspirational power of space, there are many documented pieces of evidence for its effect on society. This is increasingly true as space exploration transitions to space exploitation. The sector contributes a huge amount to the UK economy as well as maintaining its world-leading position in space science and Earth observation. The government-commissioned '*Size and health of the UK space industry 2023*' report (London Economics, 2023) illustrates the financial importance of the sector, with well over £7 billion of gross value added (GVA) to UK economic output annually from 2018 to 2022, and £364 billion of UK GDP reliant on satellite services. By comparison, similar statistics show that for pharmaceuticals, one of the UK's strongest sectors, GVA in the UK reached £13.7 billion in 2021, following a significant increase because of the COVID-19 pandemic (Office for Life Sciences, 2024). Along with financial benefits, there are many space sector jobs at a variety of skill levels and in a wide variety of occupations, from science and engineering to marketing and law.

The UK Space Agency's (UKSA) declared aim is '*to support the government to boost UK prosperity, understand the Universe, and protect our planet and outer space*'. The MOD has formed a Space Command tasked with defence applications in space, including the recent launch of *Tyche*, the first UK-built, military reconnaissance satellite for monitoring global events, from conflicts to natural disasters. A National Space Strategy was published in 2021 and, in March 2024, the government published the Space Industrial Plan (DSIT and MOD, 2024) described as '*A joint civil-defence plan, establishing clear visions, missions, and actions to unlock growth and develop resilient space capabilities in the UK*'. These agencies and initiatives illustrate the importance placed on the UK's space sector.

When the Space Skills Alliance (SSA) investigated the issue of '*How and why people join the UK space sector*', using results from the 2020 Space Census (Dudley and Thiemann, 2023), they found that '*Interest in space comes from a range of sources, including educational settings like science festivals (42%), schools (24%), and museums (23%), and media like books (36%), TV (30%) and the internet (17%)*'. However, '*School outreach has a much more limited impact (5%), despite being the focus of a lot of space skills strategies*'. In Figure 3 of their report, 30% of respondents indicated that school or a teacher was responsible for their interest, whereas only 6% cited outreach at school. This gives some indication that the influence of regular exposure to the topic, from an enthusiastic teacher or supportive school, may affect an individual's choice of career path more than external, infrequent interventions and would be a worthwhile question for further investigation.

The UK Space Skills Landscape Map (Space Skills Alliance, 2024) includes a section on education, illustrating existing initiatives funded by UKSA and others. These are all examples of programmes that reach only some students, either those with support and finance to attend specialist events or those from targeted intervention groups, such as through the inspirational Jon Egging Trust's Blue Skies Programme. None of these initiatives covers all students, especially those who might consider progression into the space sector if they knew more about its opportunities but who do not engage with activities outside their classroom experience.

The SSA, on behalf of UKSA, has reviewed the employment needs of the UK space sector and identified significant skills gaps in it (Thiemann and Dudley, 2023). These range from obvious areas such as engineering and materials to software and data analysis as well as essential support areas such as law and commercial operations. Non-STEM areas are increasingly significant as space missions become privatised and space is exploited as a resource. The Space Sector Skills Survey reports gaps of over 20% in 15 separate skill areas, that is where neither existing employees nor potential recruits have that skill. The three most significant gaps were in AI and machine learning (41%), systems engineering (39%) and data analysis and modelling (36%). While these specific skill areas are never likely to be fully addressed in a school curriculum, it is pertinent to ask, in that case, when the appropriate stage to begin addressing the issue is and how it should be done, but that is not the purpose of this current article.

## What space is there in the curriculum?

This initial review is confined to a survey of specific space-related topics in the school science curriculum from three sources:

- The National Curriculum in England (KS1–KS4) (Department for Education, 2015)
- The exam board specifications for GCSE combined science
- The exam board specifications for GCSE physics

This gives a flavour of what is set down as a statutory requirement, at least in England, and what space topics most GCSE candidates will encounter by age 16. Only physics is included as a separate subject, as this is where a specific space topic usually occurs. The Welsh Joint Education Committee (WJEC) specification is included as this is not exclusive to students in Wales, but additional specifications, such as International GCSEs or Entry Level Certificates taken by a smaller percentage of students, are not. The review does not go beyond GCSE, as its aim was to survey space content covered by the majority of students during their school career and for whom this might be the last time they encounter any formal science learning. Although the focus is on parts of the current curriculum labelled as physics, there are obvious opportunities in other areas. Chemistry specifications include the topic of Earth and its atmosphere and even comparisons with other planetary atmospheres in certain specifications. However, opportunities for enhancing the curriculum in other subjects, including subjects outside STEM, have not been addressed yet.

The first source examined was the National Curriculum in England, which lays out the statutory requirements for programmes of study (PoS) from key stage 1 to key stage 3 (ages 5–14) and gives content requirements for specifications offered at GCSE (ages 14–16) (Department for Education, 2015). Figure 1 shows the total number of individual items specified in the PoS for science for primary years 1 to 6 separately and for secondary grouped as key stage 3 (ages 11–14) and key stage 4 (ages 14–16). The number of items that are specifically space related are also shown for comparison. Across all key stages, there are approximately 375 individual items specified for students between the ages of 5 and 16 in schools in England (excluding 'Working scientifically' items), of which 11 (3%) are specifically space related. There is a three-year gap in the primary curriculum, with teaching about the seasons required in year 1 and the relative motion of the Earth, Moon and Sun in year 5. At key stage 4, where most students take GCSEs, the content of the curriculum is dictated by the specifications offered by the exam board chosen by their school. The annual summary of grades per subject published by each board (easily found by an online search, e.g. AQA – see *Useful links*) is a means of assessing the number of candidates nationally following each specification. Using June 2023 data, figures for each of the main exam boards in England and

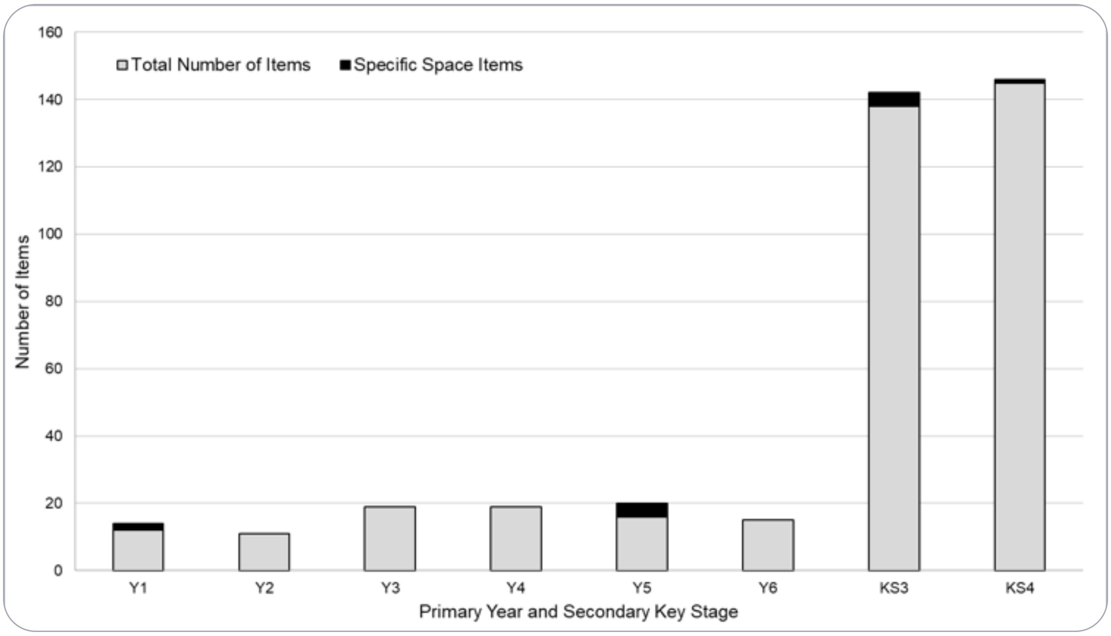


**Figure 1** The number of science content items specified in the National Curriculum in England by primary year and secondary key stage (excluding 'Working scientifically')

Wales are presented in Table 1. Some exam boards, such as AQA and OCR, offer alternative GCSE specifications, so the numbers have been combined as there were no differences in space-related content, just in the way it was organised.

Table 1 shows the breakdown of candidates taking either combined science or physics by exam board in England, with the WJEC board added for comparison as this specification may have been followed by some candidates in England. The WJEC specification also provides an interesting contrast to other boards as it contains more specific space topics in both its double-award (equivalent to combined science) specification and in separate physics. Sadly, for the majority of students in England, this is not the case, as combined science specifications

**Table 1** Number and percentage of candidates per exam board taking GCSE combined science or GCSE physics in the June 2023 exam session. Raw numbers were obtained from online searches for each exam board's results tables, and the total number of GCSE candidates in England, 699 755, was given in the Ofqual Infographics for GCSE Results 2023 on the GOV.UK website. The percentages exclude candidates in England who may have followed International GCSE specifications, Entry Level Qualifications and other courses

| Exam Board | Number of GCSE combined science candidates, June 2023 | Percentage of all GCSE candidates taking combined science in England, June 2023 | Number of GCSE physics candidates, June 2023 | Percentage of all GCSE candidates taking separate physics in England, June 2023 |
|---|---|---|---|---|
| AQA | 361 029 | 52% | 140 347 | 20% |
| OCR | 16 529 | 2.3% | 9 587 | 1.4% |
| Edexcel | 62 457 | 8.9% | 22 994 | 3.3% |
| TOTAL | 440 015 | 63% | 172 928 | 25% |
| WJEC | 18 429 | N/A | 8 372 | N/A |

offered by the three English exam boards no longer contain any specific space topic. Therefore, over 60% of students in English schools will not have the opportunity to learn about space in formal lessons during their GCSE studies. For many, these two school years will be their last opportunity to learn about any science, let alone space, in a formal context.

Students who choose to take physics as a separate GCSE subject encounter a small amount of specific learning on space as all physics specifications include a space or astronomy topic. This is often the final topic, which can lead to its being neglected compared with others at the end of a course with exams looming. An exception is Edexcel, where astronomy is topic 7 out of a total of fourteen topics. The content of all separate physics specifications is very similar across exam boards, usually including the solar system, the Sun as a star, the lifecycle of stars, galaxies, redshift and evidence for the Big Bang. This is limited in extent and other opportunities to deliver the physics through its obvious applications in space exploration are not suggested.

As mentioned, the WJEC specifications include a larger range of space items as well as setting them out in more detail. For example, their double-award topic 6 on space lists:

- The main features of our solar system, their order, size, orbits and composition to include the Sun, terrestrial planets and gaseous giant planets, dwarf planets, comets, moons and asteroids.
- The use of appropriate units of distance: kilometres, astronomical units (AU) and light years (ly).
- The fact that the stability of stars depends on a balance between gravitational force and a combination of gas and radiation pressure.
- Stars generate their energy by the fusion of increasingly heavier elements.
- The return of material, including heavy elements, into space during the final stages in the life cycle of giant stars.
- The origin of the solar system from the collapse of a cloud of gas and dust, including elements ejected in supernovae.

WJEC higher tier candidates are also required to know about the Hertzsprung–Russell diagram, a practical tool in astronomy only encountered at A-level in other boards.

This review of both National Curriculum PoS and exam board specifications for science GCSEs therefore shows a very small, or even non-existent, coverage of specific space topics in the current curriculum and no specific mention of space flight or space exploration at all.

## How can more space be included in the curriculum?

The inclusion of every specialist topic and societal issue in the school curriculum is an impossible task because of the number of subjects covered, the quantity of essential learning points required and the plethora of problems that campaigners wish schools to address. There is also a danger in encouraging students to overspecialise in one area, which is well known to be a feature of the UK education system that employers have concerns about. However, studies have shown clear evidence for the inspirational nature of space: quantitative research on the views of over 8000 students from 11 European countries demonstrated enthusiasm for, and positive attitudes towards, space among the 9- to 16-year-olds surveyed (De Witt and Bultitude, 2020). The significant influence of teachers and schools on the career paths chosen by those now working in the UK space sector was also mentioned earlier (Dudley and Thiemann, 2023), strengthening the case for an embedded approach in schools rather than wrap-around initiatives delivered by outsiders. Is this possible, however, without increasing content and teachers' workload, or risking overspecialisation?

A review of current GCSE specifications reveals some interesting comparisons between the level of detail given in different subjects, especially in biology and physics topics. For

**Table 2** An example framework for developing a space-themed lesson to enhance learning of circular motion at GCSE

| **Specification item** | Students should be able to explain qualitatively, giving examples, that motion in a circle involves constant speed but changing velocity |
|---|---|
| Concept hierarchy | • Recap definitions of speed and velocity<br>• Circular motion requires acceleration towards the centre<br>• Acceleration requires a force to act (Newton's first law)<br>• Velocity can be represented as a vector with components in two perpendicular directions<br>• Motion in a circle requires acceleration in one of these directions and deceleration in the perpendicular direction<br>• Velocity is therefore constantly changing, increasing in one direction and decreasing in the perpendicular direction, while speed remains constant |
| Examples of circular motion | Common examples:<br>• a playground roundabout or spinning wheel<br>Less common examples:<br>• a turbine blade or an aeroplane in a loop<br>Examples in space, current and future:<br>• orbiting satellites/moons/planets |
| Forces that cause circular motion (also called centripetal forces) | • Mechanical tension in wheels<br>• Friction in turning corners<br>• Lift in a looping aircraft<br>• Gravitational force in orbits |
| Example space-related extension skills | By hand or using spreadsheets, plot graphs of:<br>• satellite orbit radius vs speed using data from www.esa.int/Enabling_Support/Space_Transportation/Types_of_orbits<br>• planetary orbit radius vs speed using data from https://nssdc.gsfc.nasa.gov/planetary/factsheet<br>Use the graphs to predict speeds of objects at other radii.<br>Research and present on the meaning and uses of Low Earth Orbits (LEO), Medium Earth Orbits (MEO), Polar Orbits and Geostationary Orbits. |
| Example space resource links | Animated demonstration of orbital motion: https://phet.colorado.edu/sims/html/gravity-and-orbits/latest/gravity-and-orbits_all.html<br>Principia Mission demonstration video clips: https://astroacademy.org.uk/resources/circular-motion<br>Satellite applications activity: www.stem.org.uk/resources/elibrary/resource/34031/which-satellite-am-i |
| Example space careers links | People who need to understand circular motion in their jobs: https://spacecareers.uk/articles/08f9e7d3-4a9d-4411-b12d-f088a4b95fdd<br>www.stem.org.uk/resources/elibrary/resource/26079/spacecraft-engineer |

instance, the biology topic of drug discovery and development is always accompanied by a list of exactly what learning is required, such as: describing the process of discovery and development of potential new medicines; preclinical and clinical testing; explaining that drugs were traditionally extracted from plants and microorganisms, with the specific examples of digitalis, aspirin and Penicillin. This gives a teacher, particularly a non-specialist, clear understanding of what to cover. By contrast, choosing the physics topic of circular motion as an example with links to space, teachers are given very little detail. Typical specifications require students to be able to explain qualitatively that motion in a circle involves constant speed but changing velocity. Some specifications stipulate that relevant examples should be given but do not say what these are, a great disadvantage for non-specialists. Circular motion is also a higher tier topic, excluding a significant number of foundation tier candidates from an opportunity to learn about a space application. Certain exam boards suggest a demonstration of whirling a rubber bung on a string. This is obviously fun and easy, following an appropriate risk assessment, but simply whirling a bung on a string does not help students to make connections with circular motion in the real world unless teachers are equipped with guidance and resources to allow them to do so.

Table 2 gives a planning structure showing the detailed knowledge pathway needed to explain the circular motion concept as required by the specification. In addition, there are suggested extension activities with links to other topics and resources, opportunities for skills development and relevant career-profile links. The importance of including career links as a standard part of STEM learning was shown by Reiss and Mujtaba (2017), as raising students' awareness of the reasons for their learning is often not prioritised. This structure is suggested as a starting point from which specific lesson plans could be developed, particularly with the aim of supporting those who are not subject specialists to deliver well-informed lessons. Many more opportunities abound in the physics area of the curriculum to develop similar, space-themed plans. Ultimately, areas outside physics and outside STEM could also be explored, with subjects such as geography and business studies being the most obvious where space-linked resources could be offered.

## Conclusion

Any initiative aimed at using a particular theme to inspire improved learning should always be designed to help both teachers and learners. Teachers need easy access to well-written and well-structured lesson plans, including supporting materials that are relevant to the curriculum specification they are delivering. This is particularly important for non-specialist teachers who may not be aware of appropriate examples and applications of the topic. Currently, available resources for space topics rely on a teacher having the time, knowledge and enthusiasm to search for them and incorporate them in their own lesson plans. A well-structured and curated approach to sharing these resources would help teachers to access and use them much more effectively and on a regular basis.

Some schools and colleges are already setting up initiatives to ensure more engagement with the inspirational topic of space, as well as directly addressing the skills gaps identified earlier (e.g. HSDC – see *Useful links*). However, with the current lack of space-specific inspiration in the curriculum, will prospective students be aware of the opportunities it offers and want to work in the space sector? Current evidence shows that this will not be the case for most students by age 16. The approach presented here, of developing structured, curriculum-linked and space-themed resources available to all teachers, is a key way of engaging the majority of students with the inspirational opportunities and relevance of space in their science lessons. Existing, high-quality, space-related education programmes may inspire a few but do not affect the majority of students.

## USEFUL LINKS

AQA GCSE statistics June 2023:
https://filestore.aqa.org.uk/over/stat_pdf/AQA-GCSE-STATS-JUN-2023.PDF

HSDC (Hampshire and South Downs College) Space Technologies Programme:
www.hsdc.ac.uk/home/space-technologies-programme

## REFERENCES

Bennett, J., Airey, J., Dunlop, L., and Turkenburg, M. (2018) T*he impact of human spaceflight on young people's attitudes to STEM subjects. Final report to the UK Space Agency and ESRC, January 2018*. York: University of York Department of Education.

DeWitt, J. and Bultitude, K. (2020) Space science: the view from European school students. *Research in Science Education*, **50**(5), 1943–1959. https://doi.org/10.1007/s11165-018-9759-y

DfE (2015) *National Curriculum in England*.
www.gov.uk/government/publications/national-curriculum-in-england-science-programmes-of-study

DSIT and MOD (2024) *Space industrial plan*. www.gov.uk/government/publications/space-industrial-plan

Dudley, J. and Thiemann, H. (2023) *How and why people join the UK space sector. Space Skills Alliance*.
https://spaceskills.org/census-routes#summary

Endeavor (2019) *Celebrating Apollo 11: Inspiring STEM educators for 50 years*.
www.us-satellite.net/endeavor/apollo11.cfm

IPSOS (2019) *Attitudes towards space exploration*. www.ipsos.com/en-us/news-polls/cspan-space-exploration-2019

LEGO (2019) *The LEGO group kicks off global program to inspire the next generation of space explorers as NASA celebrates 50 years of moon landing*. www.lego.com/en-in/aboutus/news/2019/july/lego-group-kicks-off-global-program-to-inspire-the-next-generation-of-space-explorers-as-nasa-celebrates-50-years-of-moon-landing?locale=en-in

London Economics (2023), *Size and health of the UK space industry 2023' study launch*.
https://londoneconomics.co.uk/blog/press-event/size-health-of-the-uk-space-industry-2023-study-launch

Office for Life Sciences (2024) *Life sciences competitiveness indicators 2024: summary*. www.gov.uk/government/publications/life-sciences-sector-data-2024/life-sciences-competitiveness-indicators-2024-summary

Reiss, M. J. and Mujtaba, T. (2017) Should we embed careers education in STEM lessons? *The Curriculum Journal*, **28**(1), 137–150. DOI: 10.1080/09585176.2016.1261718

Space Skills Alliance (2024) *The UK Space Skills Landscape Map*. https://spaceskills.org/landscape

Thiemann, H. and Dudley, J. (2023) *Space sector skills survey 2023 results*.
https://spaceskills.org/space-sector-skills-survey

**Jeremy Thomas**
*is an Outreach and Public Engagement Fellow at the Institute of Cosmology and Gravitation, University of Portsmouth.*
jeremy.thomas@port.ac.uk