British Planetaria and the National Curriculum

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1. Introduction

The UK is experiencing a relative Golden Age for planetaria, thanks in many ways to its national curriculum. In 1991 the British government finally bowed to many years of steady pressure by interest groups and introduced into a new and controversial general curriculum a requirement for pupils to attain knowledge about the Earth-Moon system, solar system objects and basic cosmology. Prior to this there had been no science curriculum for pupils aged under 11. Astronomy formed a small part of nature study. The science education of 11-16 year-olds depended on their GCSE syllabuses.

The purpose of this paper is to study what knowledge of the cosmos pupils are now required to attain, how the content changed when a revised curriculum was introduced in 1994, and how planetaria go about teaching the subject to schoolchildren. We will also look at how the curriculum differs in Scotland, and what 'A' level students have to learn about astronomy.

2. Background

From the late 1950s, when one of the first planetaria in Britain was built at Marylebone Road, London, up to 1991, some teachers had organised their school visits to these star theatres as an extra-curricula activity (except for those students studying astronomy at O-level) which required little or no preparation or class work afterwards. Generally speaking, however, most school parties turned up because they wanted to have a valuable learning experience about the Earth's place in the universe. Then, seemingly overnight, the government expected teachers to have detailed knowledge of the reasons for the seasons, tides, the Moon's phases, planetary motions, the Milky Way and many other difficult astronomical concepts. The radical changes in all subjects in the new curriculum caused problems in the education profession for a considerable time, and gave teachers a wide knowledge gap to fill.

Astronomy resources to help educators in their daunting task were available, scattered though they were over a number of publications not intended specifically for classwork, but unfortunately teachers did not know where to look for them and who to contact for more information on the necessary teaching methods. They desperately needed help, and so after having spent several decades on the fringe of school science education, British planetaria were ideally placed to lend a helping hand to a grateful teaching profession.

The planetarium scene in the UK is markedly different in some ways to that in the USA. The shock launch of Sputnik in 1957 sparked off a huge investment in American school science education. Within a few years hundreds of schools and colleges across the nation had built planetaria in their grounds, and to this day most domes are to be found there. In the UK, however, the trend up until the late 1980s had been for domes to spring up linked mainly to universities, museums and observatories such as those at Greenwich, Jodrell Bank, Liverpool, Armagh and Edinburgh. Schools had no option but to take coach parties of children to these places for their astronomy experience under the

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simulated stars, since barely a handful of domes were (and still are) directly linked to schools.

With the new curriculum, however, the scene was wide open for development by the cost-effective, American-designed Starlab mobile inflatable dome, which was destined to add a new dimension to astronomy education and greatly increase the number of pupils who could have the planetarium experience each year. Sure enough, the number of inflatables grew rapidly, satisfying tens of thousands of children and their relieved teachers. At the time of writing there are at least 23 Starlabs in the UK (several of which are owned by Local Education Authorities) and this figure represents roughly half of all British domes. Thanks largely to the curriculum, many of them are run as commercial concerns in different areas with arbitrary borders that do not infringe on other people's unofficial territory. Yet there are still large regions containing many schools not serviced by either a portable or fixed dome.

Traditionally, British planetarians have not been as technology-obsessed as their American cousins, but in the 1990s the equipment used at some of the larger domes has been brought up to date if only to address the expectations of audiences accustomed to sophisticated software in PC packages and video games, and the special effects seen in films. Several years ago technicians at the Armagh Planetarium, Northern Ireland, developed the world's first electronic interactive equipment which was later adopted by the dome at the National Galleries and Museums on Merseyside, in Liverpool. The design has since been copied by many other sites across the USA. Armagh now has a Digistar projector which creates computer-generated star images. The London Planetarium has also acquired one which was brought into service in 1995; this new technology has enhanced their school shows, opening new areas that could not be exploited with their old mechanical Zeiss star projector (which had long and faithful service from 1958 to 1994). Digistar's excellent graphical capabilities make topics such as planetary orbits and black holes easier to explain.

3. The 1991 national curriculum

The 1991 national curriculum was administered by the then Department of Education and Science and is taught in over 30,000 schools across England, Wales and Northern Ireland. Children aged 5-11 attend primary school, after which they move on to secondary school until the age of 16. Pupils aged 16 upwards have the option of studying subjects at 'A' level, a qualification which is needed if they hope to go on to university.

The curriculum divides the process of learning into four distinct Key Stages of increasing complexity. The astronomy content at every Key Stage in the old curriculum was grouped under the heading "The Earth's Place in the Universe". Key Stage 1, for pupils aged 5-7 still learning the basics of the world around them, required children to study a) the Sun's apparent daily motion across the sky, b) the Earth, Sun and Moon as separate spherical bodies, and c) the changing altitude and appearance of the Sun and Moon over time in a predictable manner. Children discovered that the Earth is a spinning planet which orbits the Sun, and these two factors cause night and day.

Key Stage 2, for ages 7-11, covered similar ground with the additional requirement of needing to learn that a) light travels faster than sound, b) the lengths of day and night and the year are determined by the Earth's motion round the Sun, c) the reflection of light enables objects to be seen in the sky, and d) the other planets in the solar system move in their own orbits.

Key Stage 3, for pupils aged 11-14, went deeper by looking at a) the Sun as the Earth's major source of energy, b) the solar system as a small part of a galaxy within a much

larger Universe, and c) the properties of gravity and the fact that its force diminshes with distance.

Pupils aged from 14-16 in Key Stage 4 completed their basic astronomy education with a study of a) how energy is conducted by radiation, b) the quantative relationship between speed, frequency and wavelength of radio signals, c) the use of data about the planets and stars to speculate on conditions elsewhere in the Universe, d) the electromagnetic spectrum and how specific wavelengths are detected, e) gravitational theory as it relates to the motion of satellites, and f) theories about the origin and future of the Universe, and the observational evidence in support of them.

Once the dust had settled following the new curriculum's launch, and teachers had a grasp of the subject matter above with the help of the professionals, they were, broadly speaking, happy with the astronomy content.

The resulting new planetarium school shows were not put together in a vacuum. Local teachers were brought in at an early stage to be an active part of the programming. Sometimes they asked for certain topics to be omitted, as they were confident about covering those with relative ease in the classroom. Essentially, they wanted planetarians to use the star and planet projectors to explain the difficult concepts, such as lunar phases, planetary motion, constellations, time, seasons, daily changes in altitude and annual motion, that could not be done adequately in a classroom environment.

The shows were (and still are) almost exclusively live, and teachers often learned as much as their pupils, and they didn't mind if the presenter went off on a tangent (which was easily done, as so many topics in astronomy share common ground). They were surprised at the relative ease with which planetarians could explain complex concepts. It's amazing what you can do with an Earth globe, polystyrene balls and light bulbs! The experience sent them back to their classes feeling more confident about their ability to teach the subject.

The emergence of Starlabs has fortuitously coincided with a period in British education when schools are increasingly strapped for cash, and every pound spent has to be justified. The inflatables have therefore become popular with teachers for several reasons. To begin with, they do not have the time-consuming duty of organising a visit to a fixed dome, secondly the overall cost of inviting a Starlab operator to come on site for a few days is cheaper per pupil, and last of all the shows can be slotted into the school's schedule with relatively little disruption.

Schools were anxious for quality teachers notes to assist them with the new curriculum, and so the Association for Astronomy Education (AAE) a small but influential organisation, filled a gap in the market by co-publishing with the Association for Science Education (ASE) two sets of activities for primary and secondary children, under the title *Earth and Space*. With significant help from planetaria, approximately 16,000 copies have been sold to date, the majority to the teaching profession, and in 1996 updated editions will appear, incorporating the requirements of the revised 1994 curriculum.

Another aid for teachers has been the In-Service Training courses hosted by planetaria. They visit for either half a day or a whole day of practical demonstrations, which are designed to answer common questions about the practicalities of teaching astronomy in a classroom.

A similar idea organised by the Royal Astronomical Society (RAS) has been equally successful. Their regular Training the Trainers one-day courses continue to be well attended by teachers.

In recent years some British planetaria have turned to the acting profession for help with teaching the curriculum. Inter-Action, an educational charity which develops innovative learning and community projects and is based on the HMS Belfast (a decommis-

sioned warship moored on the Thames at the *Victoria* Embankment) employs actors on short-term contracts to travel the country with several Starlabs. The actors use their drama training to present shows in a fanciful piece of drama and comedy, slipping in and out of the numerous mythological characters that fill the night sky. This highlights the more human face of astronomy for children, and the regular influx of fresh staff generates new ideas for shows.

In a similar vein, Peter Joyce, a professional actor, has become a familiar and welcome guest at planetaria, where he appears dressed as either Sir Isaac Newton or Galileo. As Newton, he regales his audience with tales of how history's greatest scientist developed his theories of planetary motion and gravity. To demonstrate the universal force, he picks a female from the audience and tells her he is attracted to her! Gravity then allows him to move to other areas, such as the Moon's motion round the Earth, tides and satellites in geostationary orbit. The appreciative audience are left in no doubt how much of what we take for granted today has its roots in his ground- breaking observations and insights.

As Galileo, Joyce relates the Aristotlean geocentric theory and talks of his own experiments dropping cannonballs from the leaning Tower of Pisa, and firing them from a cannon to study the force of gravity. Pupils also hear about the Copernican heliocentric revolution, and Kepler's studies which lead to the formation of his laws of planetary motion. Galileo reveals his delight with his first telescope and the wonder of discovering Jupiter's four largest moons, which his audience learn they can see for themselves with modest equipment.

3.1. *The 1994 curriculum*

In 1994, after several years of intensive lobbying from a teaching profession still having difficulties coming to terms with the new curriculum in every subject, the government finally scaled down its scope across the board to give teachers more time on each subject. There was a general feeling that, difficult though some aspects of the astronomy curriculum had been for teachers, overall it had been a success and popular with pupils. Organisations such as the AAE, ASE and RAS were consulted by the government for their advice on reshaping the astronomy content, and their feedback was largely adopted. The revised curriculum omits almost all mention of the subject in Key Stage 1, but as teachers had found that in the old curriculum 5-7 year-olds had difficulty with the concept of lunar phases, some of these changes were welcomed. The only astronomy topic Key Stage 1 now touches on is under the heading Light and Sound, which requires pupils to know that "light comes from a variety of sources, including the Sun", and that "darkness is the absence of light". Teachers who now want to talk astronomy at Key Stage 1, have to be creative and bring in the subject via areas such as Geography or History.

The amendments to the astronomy in Key Stages 2 and 3 (now found under "Earth and Beyond") were less radical, although the reasons for tides was the most notable omission.

3.2. *Teaching the curriculum*

Planetaria take a variety of approaches to teaching the curriculum. We shall study several of them.

Every year the London Planetarium caters for approximately 20,000 pupils who come through its doors to see curriculum-based shows. Teachers are given a comprehensive pack of support material which can be utilised in the classroom. It includes a quiz which tests pupils' astronomy knowledge before and after their visit, basic facts about constellations and deep sky objects and a solar system poster. For teachers there is a list of contacts for resource material, such as videos, books, telescopes, binoculars etc.

The exhibition area is divided into several distinct sections. In Planet Zone our nearest neighbours in space are the focus. Scale models are accompanied by video pictures and text with up-to-date information about each planet, whilst touch-screen monitors supply facts about comets and meteors etc. Other screens display information about tides, satellite orbits, the solar system's birth, the Sun's energy production, large-scale galaxy structure and what is visible to the naked eye in the sky at the current time. This area also has a three-dimensional model of the stars in the constellation Orion. Visitors see that the stars are at different distances from Earth, and it is a line-of-sight effect that makes them appear to us in the familiar pattern.

The other key area, Space Zone, also has touch-screens which cover more exotic subject matter such as star birth, stellar evolution, solar fusion, planet formation, cosmology, black holes etc.

The planetarium's Key Stage 1 show goes beyond the revised curriculum's limitations and, after introducing children to the concept of night and day and the motion of the Earth round the Sun, the Digistar II projector cleverly turns the planetarium into an imaginary spaceship that launches out of the dome of an imaginary observatory to explore the solar system. The audience land on the Moon and Mars, and travel to the outer reaches of our solar system before flying home.

The show is popular with pupils and teachers alike. So, too, are the other Key Stage shows, which give the audience more than the curriculum leads them to expect. The Key Stage 4 show climaxes with gasps of delight, as the audience is sent on an exciting trip down into a black hole.

In 1996 the planetarium successfully inaugurated what is hoped will become an annual nationwide Schools' Challenge Quiz, entitled "Rising Stars". It was a knockout competition featuring teams from 23 London schools competing for a Russian-made reflecting telescope. Some of the questions were based round constellations and other images on the dome.

At the Armagh Planetarium in Northern Ireland the pupils themselves are used as human models to explain seasons and lunar phases. They take advantage of a permanent scale model of the solar system situated in an Astropark, 25 acres of ground next to the planetarium. The dome houses a Digistar projector which displays a 3-D orrery, useful for explaining orbits and eclipses. The planetarium also has an outreach program, consisting of a purpose-built Astrovan which takes hands-on activities and a Starlab to schools. It caters for approximately 15,000 pupils each year.

Staff at the South Shields Planetarium in the north-east of England take a fresh angle on old and tried topics. For example, children are given worksheets that encourage them to count the number of feet in the zodiac constellation figures, and to discuss what happened to the Seventh Sister in the Pleiades! They also take part in light-hearted, fun astronomy quizzes and build fantasy rockets to explore the solar system.

Many planetaria give children information sheets containing basic facts about astronomy, encouraging them to look at the real sky and follow the Moon's phases, identify naked-eye planets, the larger constellations and do basic experiments with shadow sticks. Pupils also learn how to make simple inexpensive sundials, nocturnals, planispheres, build scale models of the solar system from cheap household items and design their own constellation shapes. At the South Shields dome simple rockets are launched with compressed water, and a Junior Astronomy Club meets regularly. A similar idea has proven successful at the Fort Victoria Planetarium, on the Isle of Wight, which hosts regular meetings of its Starlog Club for children. At Techniquest in Cardiff, pupils view sunspots on the projected solar surface.

The company Inter-Action believe that Starlab's adaptability is one of its greatest

strengths, and that using the dome for nothing but astronomy shows will not utilise its full capabilities. In recent years they have found success developing new cross- curricula shows to cover other aspects of science in the national curriculum, some of which share common ground with astronomy. This innovation allows them to discuss topics which would not sit comfortably within a standard show about the night sky. It points the way forward for other Starlab operators who are thinking of expanding their scope, whilst staying true to their astronomy roots.

Before the revised curriculum was published, planetarians got wind of the changes and many of them, especially the sole-operators whose income derives largely from their Starlab curriculum-based shows, looked on it with foreboding. They foresaw their livelihood being seriously eroded overnight. However, the clear message from planetarians across the country since the changes were introduced could be summed up as, "Changes? What changes". Generally speaking, it appears that many teachers are happy to let them continue with more or less the same breadth of shows they were hosting under the old curriculum.

Extrapolating from a straw poll I conducted for the purpose of this paper, it appears that well over 500,000 schoolchildren visit British planetaria every year to attend curriculum-based shows. That figure will grow as more Starlabs and other fixed domes which are being planned today open for business. This is a tribute to both the effectiveness of those school presentations, and the enduring popularity with children of basic astronomy concepts which excite their imagination.

4. Scottish school astronomy

The national curriculum is not taught in Scotland. Their schools are instructed to cover specific broad subjects, such as Science, History, Music, etc., and it is left to teachers to decide what elements of those subjects they cover. Science gives them a convenient, broad scope, and fortunately many teachers plump for basic projects on Space and Astronomy simply because these have a proven track record with children at all levels.

Scottish planetaria tend to confine their schools programs largely to what pupils can see in the night sky, although some of the hands-on experiments offered at the Mills Observatory Planetarium in Dundee include such things as counting the numbers of galaxies and the lengths of cometary tails on large Schmidt plates, constructing simple planispheres and orrerys and studying small meteorite samples.

5. A-level Astronomy

Students hoping to get into university need to acquire qualifications at 'A' level. However, no examining board offers Astronomy at this level. Interested students can take a two-year 'A' level Physics course, one module of which is Astrophysics. The subject has been growing increasingly popular in recent years. Topics covered depend upon what examining body administers the course, but the common ones include: the microwave background, line spectra, the H-R diagram, the association between mass and energy, measuring distance by parallax, mass in binary stars, the fusion process, the transfer of energy to a star's surface, stellar evolution, black body radiation, red shift, special relativity, the Doppler Effect, the different means of classifying stars, the physics of optics and the Big Bang, etc.

6. Conclusion

British planetaria and the national curriculum have a lot for which to thank each other. Important ties have developed between planetarians and the teaching profession, ties which have given the former a respected position to comment upon and influence astronomy education in the UK. The increasing number of schoolchildren who see curriculum-based shows augers well for the planetarium profession, at a time when its finances are being squeezed from all sides. Teachers have gained much and will benefit still more in the years to come.

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