Criteria for the Diploma qualifications in science at foundation and higher levels

Principal learning

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Contents

Ofqual

Ofqual, the Office of the Qualifications and Examinations Regulator, is the new regulator of qualifications, exams and tests in England. It ensures children, young people and adult learners get the results their work deserves, that standards are maintained and that qualifications count now and in the future. We also make sure that the qualifications available meet the needs of learners and employers.

The government will be bringing in legislation to establish Ofqual as the regulator of qualifications. Until this legislation is passed, Ofqual will operate as part of the Qualifications and Curriculum Authority. Afterwards, Ofqual will be accountable to parliament.

Purpose

The purpose of this document is to record a full set of criteria for level 1 and 2 principal learning qualifications for the Foundation and Higher Diplomas in science. It also sets out the overall aims of the Diplomas in science.[1]

This document should be read in conjunction with the Ofqual document *Criteria for accreditation of Foundation, Higher and Advanced Diploma qualifications* (Ofqual/08/3990) at www.ofqual.gov.uk/files/OAC_diplomas_v2.pdf, which defines the overarching criteria for all Diplomas at foundation, higher and advanced levels, and the *Line of learning statement in science* produced by the Diploma development partnership representing the industries covered.

All references to guided learning hours (GLH) within this document are for the purposes of ensuring that at each level, there is sufficient content specified to enable the design of qualifications. GLH are not intended to indicate final unit sizes or design.

The purpose of the line of learning criteria is twofold:

- to provide the regulatory tools (alongside the overarching criteria) that the regulators will use to accredit qualifications that are developed for the Diploma and to admit qualifications and/or units of accredited qualifications into the Diploma catalogue
- to specify the requirements against which awarding organisations will develop their principal learning qualifications for the Diploma.

[1] Principal learning is taken at level 1 for Foundation Diplomas and level 2 for Higher Diplomas.

Aims

The general aims of the Diplomas are identified in Section 2 of the document *Criteria for accreditation of Foundation, Higher and Advanced Diploma qualifications* (Ofqual/08/3990).

The purpose of the Diploma in science at foundation and higher levels is to develop and extend learners' awareness of the world of science. It is for all learners and has particular relevance to learners aged 14–19 who seek to acquire knowledge and develop skills in the broad context of science.

Principal learning provides the essential knowledge, skills and understanding for all learners within the sector(s) covered. Specialist learning enables learners to acquire a deeper understanding and/or application of the topics covered in principal learning or to explore a related topic with a more local focus.

Each Diploma in science will:

- enable individuals to acquire relevant personal, learning and thinking skills (PLTS) in a science context
- give opportunities to practise and acquire essential functional skills in English, mathematics and information and communication technology (ICT), which are relevant to the level and delivered in the context of science
- enable learners at levels 1 and 2 to progress to level 2 and 3 qualifications both within and beyond the line of learning
- support progression to other Diplomas and to further education, apprenticeships, training and employment both within and beyond the line of learning
- aid effective transition to further education, work-based learning or higher education and to working life by providing a wide range of transferable skills and knowledge
- provide a motivating learning experience, through a blend of general education and applied learning within a coherent and stimulating programme.

Vision[2]

The purpose of the Diploma in science is to offer an alternative learning experience at foundation and higher level which has been developed to enthuse and engage those learners who will benefit from acquiring scientific knowledge in an applied and meaningful context; for those who will be motivated by acquiring scientific knowledge and understanding in a purposeful, work-related context. These learners will be motivated and gain skills and understanding through using practical activities for authentic purposes. They will develop an understanding of key scientific ideas and be able to apply mathematical and ICT skills.

At foundation level learners will be introduced to science in the world of work, looking at how science is used by people in their work and the impact that science has on society and the world we live in. At higher level, learners will gain a deeper understanding of scientific concepts by applying and testing models and theories in a range of contexts.

The Diploma in science offers:

- authentic work-related learning
- a multidisciplinary approach to solving problems, reflecting how science is carried out in the real world
- innovative teaching, learning and assessment.

The Diploma in science will achieve this by fostering imaginative and innovative approaches to teaching, learning and assessment and by bringing together learners, teachers and day-to-day practitioners to blend workplace technologies and practices with interactive, enquiry-based learning. During their studies, learners will acquire the tools that real scientists and industries use in taking a multidisciplinary approach to the major challenges and big questions facing humanity today.

The Diploma in science aims to:

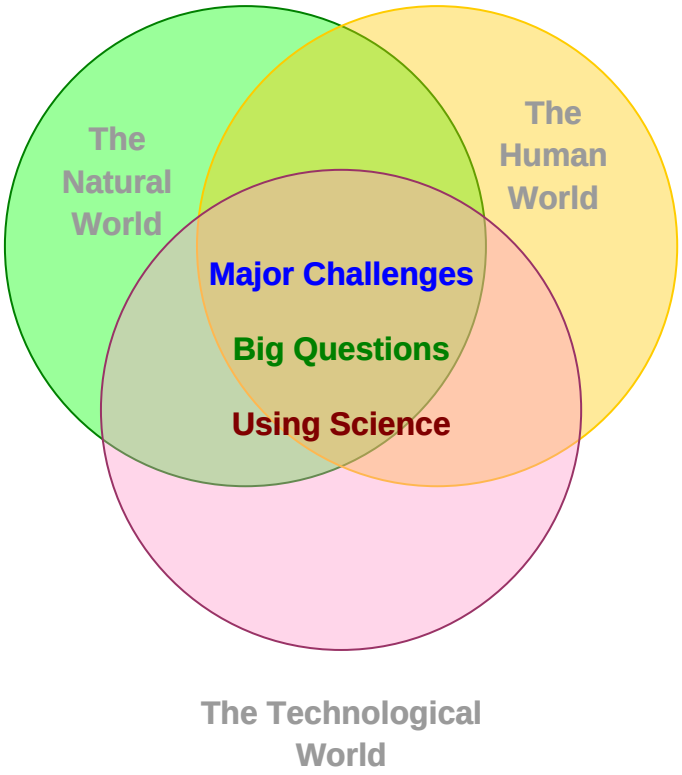
- engage and enthuse learners, extend their knowledge, understanding and capabilities, and raise their aspirations and ambitions

[2] This section is drawn from the line of learning statement for the Diploma and has been developed by the Diploma Development Partnership.

- develop an enthusiasm for learning about science and an understanding of how that learning can be effectively translated into marketable, practical and intellectual scientific skills
- provide a solid base of scientific knowledge, understanding and methodology
- emphasise the importance of being able to transfer scientific skills, knowledge and understanding learned in one context to new situations
- provide a hands-on approach to acquiring scientific skills and knowledge, illustrating the benefits of scientific methods and their broader application to problem-solving
- ensure learners develop an appropriate understanding of mathematics and ICT which they are able to apply in a scientific context and so give depth to their studies
- raise learners' awareness of the impact of science on society, now and for future generations, and the contributions they can make to scientific endeavour
- provide an insight to future trends in science, big questions that science strives to answer and challenges to be faced now and over the next 10 to 20 years
- show how people use science in different ways depending on the environment and sector in which they work
- provide insight into the application of science to real-life issues, including investigating natural behaviour, processes and phenomena; driving innovation and development, and improving the quality of life now and for generations
- enable learners to understand how scientific problem-solving methods are useful life skills
- demonstrate the role of ICT in the advancement of modern science
- enable learners to find out about career pathways in the science sector, and the huge number of opportunities that become available by studying science post 16 at level 3 and beyond.

Learners will create personalised learning programmes in line with their specific progression aspirations by choice of project, work experience and additional and specialist learning to complement the core of principal learning.

Structure of the Diploma in science



We live and work in three interlocking worlds: the natural world, the human world and the technological world. At the centre is an interlinking series of major challenges and big questions, together with the knowledge, understanding and skills to tackle them. Over time these will change, and the Diploma in science will not teach fixed answers to them. Rather, it prepares learners for a world in which there will always be uncertainty and where new challenges and questions emerge, whether big or small, each generation must be equipped to address them. They will see how they might contribute creatively and innovatively to future scientific activity, and when asked to deal with an unfamiliar situation or problem, be able to adapt and respond readily and effectively without being intimidated.

Major challenges

- Providing adequate food and water supplies worldwide
- Ensuring lifelong health and wellbeing for all
- Managing environmental change and biodiversity
- Meeting demand for energy and raw materials sustainably
- Securing global stability

- Harnessing emerging technologies

Big questions

- How did the universe come about?
- What are the buildings blocks of matter?
- Why are changes constantly happening in our world?
- What was the origin of life?
- How do living organisms function?
- How do our brains work?
- Is there life on other worlds?

Using science

- Identifying problems and current knowledge, and generating testable questions
- Considering potential social, human and environmental impact, the welfare of organisms, health and safety, and ethical issues
- Collaborating with others and deploying resources effectively and efficiently
- Applying scientific ideas, theories and models, while challenging accepted ideas
- Solving problems and answering questions using practical and investigative techniques creatively
- Gathering, analysing and evaluating evidence and data
- Communicating knowledge, expertise, and implications of scientific work

Key stage 4

Principal learning for the Diploma in science at foundation and higher levels will encompass the full national curriculum programme of study for science at key stage 4. Learners taking the Diploma will also have the opportunity to apply key concepts and processes from the key stage 4 programme of study for mathematics in a range of scientific contexts that will help support and strengthen their knowledge and understanding of mathematics.

There are many opportunities within principal learning for the development and application of skills in ICT, both in relation to specific scientific applications and also more generally in relation to accessing, recording, presenting and interpreting data.

As part of the qualification development process, curriculum guidance will be produced which will include examples of opportunities to develop and exploit connections between principal learning in the Diploma and learning in other areas at key stage 4 through the statutory programmes of study, and entitlement areas. The aim of this guidance is to support consortia in designing coherent learning experience for each leaner on their Diploma programme.

Principal learning

The topics that comprise principal learning are organised around the essential ideas, skills, knowledge and understanding that can help to provide potential solutions to major challenges and answers to big questions. They are underpinned by the processes of science – rigorous methods applied with due consideration to social impact, ethical issues and human and environmental consequences. Learners will be able to apply these same rigorous scientific methods to tackle smaller, but nonetheless important, challenges and questions.

Principal learning will instil an enquiry and problem-based approach and place the understanding of scientific ideas, together with practical and mathematical skills, at the core of learning. The knowledge, skills and understanding of 'How science works' in the key stage 4 programme of study are integrated across the principal learning topics.

Practical skills will include handling of materials, apparatus and equipment, and go hand in hand with the higher-order thinking skills that underlie experimental design and the critical evaluation of data.

Mathematical skills will be developed through the units of learning where they are explicitly required at each level of the Diploma. This approach will enhance knowledge, understanding and use of mathematics in such areas as analysis and evaluation of numerical data, using statistics and estimating uncertainty.

To meet this vision for principal learning all specifications must have units that reflect the principal learning topics and that:

- provide full coverage of the key stage 4 programme of study in science
- have links to major challenges and big questions
- demonstrate contributions made by different scientific disciplines, people and organisations
- emphasise authentic workplace practices and provide opportunities for the development of relevant knowledge, understanding and skills as they relate to and support these practices

- have an applied purpose where learners draw on the knowledge, skills and understanding developed
- allow sufficient time for the development and application of:
  - practical skills and how these can be used in different situations and contexts
  - mathematical knowledge, understanding and skills in units where they are most appropriate to the scientific concepts presented
- allow learners to draw upon their own practical experiences to propose solutions to problems or meet an applied purpose
- have units that demonstrate the multidisciplinary nature of problem-solving in science.

Diversity and inclusion

Diplomas will enable all learners to be assessed by means of internal and external assessment, differentiating only on the basis of learners' abilities to meet the assessment requirement. Diplomas will use plain language that is free from bias and there will be no covert or overt discrimination in wording or content. There must be fair and equal access to the Diploma for a diverse range of learners, so that all can benefit from the high-quality applied learning in employability skills, knowledge and understanding that it provides.

Awarding organisations must design assessment requirements so that there are no barriers to achievement for disabled people, unless the barrier is explicitly justified as a competency standard in line with the *Criteria for accreditation of Foundation, Higher and Advanced Diploma qualifications* (Ofqual/08/3990). There must also be no barriers to achievement in the assessment requirements in terms of gender, race, age, sexual orientation and religion/belief.

The development of principal learning qualifications and all associated tasks of assessment, awarding and appeal, must take into consideration the needs of all potential learners to ensure that there are no barriers in terms of disability, gender, race, age, sexual orientation and religion/belief. Awarding organisations should take steps to remove any barriers, particularly for disabled learners, and where required, make reasonable adjustments. This includes the design of information and communication hardware and software, and the formatting of communication in hard copy or online.

Reasonable adjustments for disabled people must be offered where these are still needed.

Reasonable adjustments should reflect the learner's usual methods of working and not invalidate the competency standard of the assessment requirements.

Awarding organisations may allow assessment in British Sign Language. Where more than one language is used, the awarding organisations must put adequate mechanisms in place to guarantee the consistency of assessment across the different languages.

To support the requirements above, awarding organisations must have procedures in place to ensure relevant staff and associates are trained in ensuring equality in the design, development and subject matter of qualifications, assessment and awarding procedures, language used in assessment, and systems used to ensure consistency of standards across options, centres and time. They must also ensure that the centres they register do the same and use buildings that provide access for all learners in accordance with equalities legislation.

The Diploma qualification must include the identification of opportunities, if appropriate to the subject or sector, for developing understanding of spiritual, moral, ethical, social, legislative, economic and cultural issues.

Notes

Ofqual's regulation promotes equality and aims to eliminate discrimination for all the six strands of diversity in England, namely, disability, gender, race, age, sexual orientation and religion/belief.

Themes

The classification of topics under themes has not been specified by the science Diploma development partnership.

Structure

Structure of the Diploma in science			
Level	**Foundation**	**Higher**	**Advanced**
Total GLH	600	800	1,080
Principal learning (GLH)	240	420	540
Generic learning (GLH)	240	200	180
Additional/specialist learning (GLH)	120	180	360

Foundation Diploma – level 1 principal learning

Summary of topic titles

Topic no.	Title	GLH
1.1	Making useful products	30
1.2	The condition of the human body	30
1.3	Plants for life	30
1.4	Transmitting and receiving information	30
1.5	The changing world	30
1.6	Science in society	30
1.7	Testing scientific ideas	60

Topic 1.1 Making useful products (30 GLH)

Every day we use or consume products that affect our quality of life and wellbeing, for example soaps, detergents, cosmetics, drugs, foods, fuels and fertilisers. The development of these products involves people working in different areas of science and technology as well as other fields of work.

Through making, testing and using products, including their packaging, for different purposes, learners will develop an understanding of the relationship between the physical and chemical properties of materials and their uses. Learners will consider the impacts of the production and use of products on themselves, society and the environment. This will enable learners to make informed choices about benefits and possible risks associated with products they encounter.

This topic links to topics 1.5 and 1.7.

Learners must know and understand:

1. products and their packaging are made from natural and synthetic substances
2. properties of materials and how their uses are determined
3. how to determine amount of substances for production
4. physical processes and chemical reactions in obtaining and making substances
5. the characteristics of a product and how to test its effectiveness
6. consequences of not following standard operating procedures and protocols
7. how to describe the patterns of chemical reactions and changes involved in the preparation of substances
8. social and environmental implications of how products are used and made
9. implications for individuals of product choices made
10. economic and environmental impacts of energy transfer in product making
11. how to use sources of information.

Learners must be able to:

1. use mathematics to compare quantities of substances
2. use techniques to make substances

3. test fitness for purpose of substances
4. use sources of information to test ideas.

In order to engage with this topic effectively, learners must use the following PLTS:

- self-managers
- effective participators.

Topic 1.2 The condition of the human body (30 GLH)

The health and wellbeing of the human body are influenced by many factors, including the lifestyle choices of the individual. Science is able to assist us to identify the effect of lifestyle choices on the human body and manage some of the negative effects. Science cannot, however, ensure that we always make positive choices. Organisations that use science to assist in dealing with the effects of lifestyle choices include clinics, rehabilitation units, sports centres and hospitals. Greater awareness of the consequences of lifestyle choices on individuals and society could help meet the challenge of ensuring lifelong health and wellbeing for all.

Learners will explore the basic structure and function of the human body, from cells to organ systems. Through a developing understanding of the systems of the body and how they relate to each other, they will explore the effects of some lifestyle choices on the condition of the human body, with a focus on the digestive and reproductive systems. They will be aware of the risks to the health and wellbeing of the individual and society associated with some lifestyle choices. They will learn to interact with people, through real or simulated activities, in order to obtain information, appreciating the importance of confidentiality and ethics in dealing with personal information and be able to assess the level of risk associated with lifestyle choices.

Learners must know and understand:

1. basic structure and function of major systems in the human body, including the digestive and reproductive systems
2. baseline measurements of vital signs and the condition of the human body, and ways in which they are determined including observation, samples for analysis and the types of equipment used
3. positive and negative lifestyle choices including those relating to diet, drugs, exercise and sexual activity
4. the effects of lifestyle choices on digestive and reproductive systems
5. implications of lifestyle choices for the health of the individual and society
6. factors that affect lifestyle choices and the extent to which they can be influenced
7. when and how the effects of lifestyle choices can be observed

8. standard protocols and procedures used to carry out an initial health assessment including questioning techniques, use of records and who to refer to in the event of a problem

9. the importance of confidentiality when handling and storing data on the individual and how this is protected by legislation

10. how to interpret quantitative and qualitative data, including balancing what individuals tell you with scientific or statistical evidence

11. how to interact with individuals, including establishing rapport, listening and speaking and sensitivity.

Learners must be able to:

1. question people to obtain data

2. measure the condition of the human body to obtain data

3. communicate with individuals

4. interpret data, including quantitative, on the condition of the human body.

In order to engage with this topic effectively, learners must use the following PLTS:

- independent enquirers
- effective participators.

Topic 1.3 Plants for life (30 GLH)

Topic purpose

Plants are vital resources from which, through science, we are able to obtain products, including food, drugs and fuels that can contribute to meeting the major challenges of providing adequate food supplies worldwide and supporting lifelong health and wellbeing for all. Science gives us an understanding of how plants grow and how that growth can be exploited. Science also allows us to measure the effects of our exploitation of plants.

The purpose of this topic is for learners to develop an understanding of the growth of plants in different environments and how plant characteristics can be used to meet specific needs such as maximising nutritional content. Learners will become aware of the potential impact of plant cultivation methods on biodiversity in an area. Through participation in plant growing programmes and fieldwork, learners will be able to test scientific theories of plant growth and their implications for the economy, society and environment.

Learners must know and understand:

1. ways in which plants are used for essential products for the benefit of human beings
2. characteristics of plant species, their similarities and interdependencies and how they are adapted to their environment, including through inheritance
3. what is yield and how is it measured and improved
4. energy transfer and conversion in processes of photosynthesis and respiration, and factors that affect the rates of these processes
5. conditions for healthy growth and maturation of different plants
6. the structure of cells, how they multiply and the movement of substances into and out of cells
7. techniques used to grow plants and their effects, including economic, social and environmental
8. how technology is used to monitor and manage growth environments
9. how and why decisions about plant production and use are made, including those that raise ethical issues and about the social, economic and environmental effects of such decisions

10. how scientific data can be collected and analysed.

Learners must be able to:

1. plan a programme for the growth of plants
2. test soil and water
3. use tools to collect primary data
4. determine yields
5. use ICT to analyse data and draw conclusions.

In order to engage with this topic effectively, learners must use the following PLTS:

- creative thinkers
- reflective learners
- self-managers.

Topic 1.4 Transmitting and receiving information (30 GLH)

There is a limit to the distances over which humans can communicate and the speeds at which humans can communicate without artificial aids. What we can see with the naked eye, for example, is limited and our ability to see more is enhanced by spectacles, x-rays and thermal imaging. Part of the science underlying our ability to communicate is how sound and light carry energy from one place to another. Understanding this science has enabled us to improve devices and instruments and extend our ability to communicate.

This topic will introduce learners to some aspects of anatomy and physiology and the concepts of energy forms and transfers. Through exploring how we communicate using sound and images, learners will be able to recommend how the ability to do this may be enhanced by using mechanical, electrical and optical devices.

Learners must know and understand:

1. the structure and function of eyes and ears
2. energy transfers that occur when we talk, hear and see things
3. factors that limit the body's ability to receive information aurally and visually
4. what sound waves are, how they are created and carry energy from one place to another and their characteristics
5. the characteristics of the electromagnetic spectrum and how these can be used to transfer energy in the context of transmitting and receiving information
6. devices that enhance our ability to receive information aurally and visually
7. the storage and transfer of energy in devices that enhance our ability to communicate orally and visually
8. the law of conservation of energy and the concept of efficiency
9. applications and potential of communication systems
10. benefits and drawbacks of technological developments.

Learners must be able to:

1. test limits of communication devices

2. express recommendations using scientific, technical and mathematical language, conventions and symbols.

In order to engage with this topic effectively, learners must use the following PLTS:

- independent enquirers
- creative thinkers.

Topic 1.5 The changing world (30 GLH)

Many scientists work on fundamental questions about how the world we live in has developed in the way it has and the causes of that change, although there are still some questions that cannot be addressed or answered by science. Natural events such as volcanic eruptions and forest fires and human activity such as land reclamation and the burning of fossil fuels are responsible for climatic and environmental changes. To evaluate the changes taking place, reliable monitoring of the environment is necessary. From this, we can start to determine the cause of change, make predictions about change in the future and begin to contribute to the challenge of ensuring global stability.

Through this topic learners will develop an awareness of the causes of climatic and environmental change. Using fieldwork they will test an environment for evidence of change and research the potential causes of change. They will consider how science enables us to predict change and can help us to deal with the impact of change. As a result, learners will be able to suggest options for coping with environmental change.

This topic links to topic 1.1

Learners must know and understand:

1. how change has always happened in the universe but that the rate and magnitude vary
2. natural and man-made causes of environmental change
3. living and non-living indicators of how environmental change is evidenced
4. the relationships between weather patterns and climatic and environmental change
5. how technology can be used to measure change
6. how pollution and waste are monitored and controlled
7. methods for testing for pollution in an environment
8. the extent to which science and technology can predict change and deal with the aftermath of change
9. how scientific knowledge relating to environments has changed over time
10. how and why the validity of scientific information can be questioned
11. how to present options.

Learners must be able to:

1. gather environmental data
2. use ICT to simulate environmental change
3. interpret data on environmental change
4. present options.

In order to engage with this topic effectively, learners must use the following PLTS:

- self-managers
- effective participators.

Topic 1.6 Science in society (30 GLH)

Whether working to meet major challenges or undertaking more everyday tasks, many people use science in their work. Effective application of science can improve on the quality and sustainability of life. Whether seeking answers to 'big questions' or finding ways to contribute to 'major challenges', people who use science in their work operate in diverse fields, locations, work environments and organisations and they will sometimes have to make decisions about quite complex issues.

The purpose of this topic is for learners to become aware of the benefits and challenges associated with using science at work. Through primary research learners will investigate the views of people, including those who use science in their work, relating to the economic, social or environmental contribution made by science. They will explore their own values and their attitudes to science and scientists. They will consider the ethical issues that the work of some scientists presents and be able to challenge opinions on the contribution of science to the economy and society.

Learners must know and understand:

1. organisations and agencies that use science and the goals they work to
2. the science these organisations and agencies use and the social, economic and environmental contribution they make to meeting major challenges
3. the roles, organisations and agencies that use science
4. ethical considerations around scientific research and development and how individuals balance these with personal values
5. how organisations and agencies manage conflicting views of their work
6. how to conduct primary research
7. the use of ICT to analyse and present findings.

Learners must be able to:

1. conduct a survey
2. use ICT software to analyse findings
3. acknowledge values of self and others
4. present conclusions.

In order to engage with this topic effectively, learners must use the following PLTS:

- independent enquirers
- reflective learners.

Topic 1.7 Testing scientific ideas (60 GLH)

Some scientists operate in environments where their work is commercially important such as in developing cosmetics or new medicines. Other scientists may work in research to further the boundaries of knowledge rather than planning for the application of that knowledge. All scientists start with questions and ideas that need to be tested such as 'Are they valid?' and 'Would they work?' In commercial environments, this is critical as unsuccessful ideas could lead to financial losses.

In this topic, learners will explore the development of familiar products, appreciating the multidisciplinary nature of science and the value of the science behind their development. They will have time to develop team working skills as they generate and explore ideas to tackle problems. Learners will have time to devise their own tests to determine the validity of their ideas, presenting their ideas for the development of a product that is conceptually and scientifically robust enough to go to the next stage in the production process.

Topics 1.1 to 1.5 should provide the contexts on which these products and problems are based.

Learners must know and understand:

1. how to work as an effective member of a team
2. how to establish common goals for team members
3. how to evaluate outcomes against objectives
4. how to provide constructive support and feedback
5. products that have been developed with science input and the science that was used
6. how the scientific ideas behind products were developed
7. the multidisciplinary nature of the science input used in the development of products and ideas and the role of colleagues in challenging findings
8. the relationship between product development and science
9. types of tests that can be used to test the feasibility of an idea, including the process and the product's fitness for purpose
10. health and safety issues associated with conducting tests.

Learners must be able to:

1. design tests
2. collaborate with others towards common goals
3. organise resources
4. conduct fair tests
5. judge validity of outcomes.

In order to engage with this topic effectively, learners must use the following PLTS:

- creative thinkers
- reflective learners
- team workers
- self-managers.

Higher Diploma – level 2 principal learning

Summary of topic titles

Topic no.	Title	GLH
2.1	Products for a purpose	60
2.2	Maintaining health and wellbeing	60
2.3	Growth and biodiversity	60
2.4	Using energy to improve communication	60
2.5	Seeking natural resources	60
2.6	Developing analytical skills	60
2.7	Developing scientific ideas	60

Topic 2.1 Products for a purpose (60 GLH)

Every day, we use or consume products that claim to affect our quality of life and wellbeing, for example detergents, beauty products, drugs, foods, fuels and fertilisers. Modern scientific and technological methods of production have replaced some traditionally used methods and some raw materials have been replaced by synthetic materials. The manufacture, development and testing of these products involve many people working in different areas of science and technology as well as other fields of work such as marketing and sales.

The purpose of this topic is to develop learners' ability to prepare, analyse and make useful substances and materials that go into making commercial products. Learners will develop an understanding of atomic and molecular structure and how this can be used to predict behaviour of materials and reactions between substances. Learners will have opportunities to prepare and characterise useful substances and materials to determine whether they are fit for purpose and understand the importance of record keeping to inform conclusions. They will explore the economic, social and environmental impact of products, in order to enable them to make informed choices about what they buy and use.

This topic links to topic 2.5.

Learners must know and understand:

1. that useful materials are made from natural resources by chemical reactions and serve specific purposes
2. how properties of substances, determine their use
3. the relationship between the bonding and structure of a substance, its physical and chemical properties and uses
4. techniques for preparing, analysing, and modifying substances including calculating amounts, quantities and yields and the concept of the mole
5. how and why precise and accurate records are kept when preparing substances
6. how to test a substance to determine its biological, physical and chemical properties
7. how to assess the fitness for purpose of a product
8. consequences of not following standard procedures and protocols

9. how the physical and chemical changes involved in making substances can be explained in terms of the particle model, and described by using chemical formulae and balanced symbol equations and displayed chemical formulae
10. patterns in chemical reactions between substances
11. social, economic and environmental impacts (benefits, drawback and risks) of production
12. energy demands of production, transport, packaging and waste
13. drivers for historical change in production methods and the scientific enablers of those changes.

Learners must be able to:

1. use techniques to make or modify substances with specified characteristics
2. measure quantities of substances
3. use chemical formulae in calculations
4. test for specified properties
5. record data
6. interpret data to support judgements.

In order to engage with this topic effectively, learners must use the following PLTS:

- creative thinkers
- self-managers
- effective participators.

Topic 2.2 Maintaining health and wellbeing (60 GLH)

Lifestyle, diet, drugs, genetic characteristics and personal circumstances are examples of factors which affect our health and wellbeing, while interventions such as exercise, medicine, psychological therapies and surgery are used to improve them and change the way people feel about themselves. Science and technology play a major role in identifying and measuring the factors that influence our health and performance and determining how we can improve them.

The purpose of this topic is for learners to identify a range of risks to health and wellbeing. They will develop an understanding of the complexity and sophistication of the human body and be aware of how its individual systems work together in order to maintain optimal function whilst responding to a range of internal and external factors. Through research using secondary data, learners will be able to use scientific ideas and theories to recommend and explain appropriate interventions in relation to movement.

Learners must know and understand:

1. ways in which the condition of the human body is maintained and how it can be monitored
2. the range of normal values for vital signs of different individuals
3. relationships between major body systems, including cardiovascular, respiratory and musculoskeletal systems
4. how diet, lifestyle, genetic make-up and age affect health and wellbeing
5. how infectious pathogens are transmitted, identified, treated and prevented
6. principles of biomechanics
7. the mathematics and diagrams used to describe forces, motion, work and energy, including levers and moments
8. causes of lack of movement related to disease, accident and surgery
9. technologies and techniques that can be used to maintain and improve movement and fitness and the ethics and social and economic effects of their use
10. how to find and evaluate data from secondary sources
11. how to present information sensitively.

Learners must be able to:

1. determine the validity of data
2. interpret secondary research including large data sets
3. model effects of choices and conditions on individuals
4. present information about risks to individuals.

In order to engage with this topic effectively, learners must use the following PLTS:

- independent enquirers
- creative thinkers.

Topic 2.3 Growth and biodiversity (60 GLH)

The increasing demands of a growing population for food, water and space require us to find new ways to use plants and their habitats to tackle major challenges such as providing food and clean water supplies worldwide and meeting sustainable energy and chemical feedstock demands. However, humans are not the only organisms that depend on plants to survive, and because we continue to exploit plants, animals and their environments for our purposes, other dependant species are becoming extinct.

The purpose of this topic is to develop an awareness of the issues around biodiversity. Learners will develop an understanding of the functional and growth requirements of organisms and how these are managed to produce food and other commodities and how managing this growth can impact on biodiversity. Through experience of plant growth programmes, learners will test the relationships between environmental factors (including soil composition and pollinators) and plant growth and be able to propose ways to maintain the biodiversity of environments through the management of plant growth.

This topic links to topic 2.5.

Learners must know and understand:

1. ways in which plants and animals are used for essential and non-essential products for the benefit of human beings, including in less economically developed and more economically developed countries
2. concepts of inheritance, adaptation, competition, evolution, artificial selection of naturally-occurring mutations to produce varieties and genetic manipulation
3. what yield is, how it is measured and improved, and limiting factors
4. roles of biological compounds in plants and their dependence on the availability of specific elements
5. energy transfer in processes of photosynthesis and respiration and factors that affect the rates of these processes
6. conditions for healthy growth and maturation of different plants
7. the structure of cells, the control of cell processes, how cells multiply and how molecules pass into and out of them
8. the relative merits of techniques used to grow plants including intensive, monoculture, crop rotation, sustainable and organic farming

9. effects of techniques used to grow plants, including economic, social, environmental

10. legal and ethical requirements for the use and handling of plants and plant products

11. how and why decisions about science and technology are made, including those that raise ethical issues and about the social, economic and environmental effects of such decisions

12. how scientific data can be collected and analysed

13. interdependence of species

14. how to obtain data on the conditions of a local environment including soil, water and biodiversity

15. importance of and risks to biodiversity.

Learners must be able to:

1. determine the level of biodiversity in an environment

2. use tools to collect data on conditions of an environment

3. plan a programme for the growth of plants

4. use ICT to analyse and present data

5. determine yields

6. reflect on potential impacts of plant growth on biodiversity.

In order to engage with this topic effectively, learners must use the following PLTS:

- reflective learners
- self-managers.

Topic 2.4 Using energy to improve communication (60 GLH)

A characteristic of human development has been our ability to understand how our bodies function, recognise their limitations and extend our human capabilities. Examples include the way in which we are now able to communicate over increasing distances and with increasing speed. Central to this is the idea of making use of energy and the concepts of energy forms and stores and transfers, whether these take place in living organisms or manufactured devices.

The purpose of this topic is for learners to appreciate how an understanding of energy transfer, including in living organisms, can be used to develop devices to extend our communication capabilities. Learners will develop an understanding of the relationship between different forms of energy and how this has been applied to support the development of improved communication. They will have the opportunity to test the effectiveness of some of these devices and suggest improvements.

Learners must know and understand:

1. how living organisms including humans make and hear sound, see and process images and transmit information
2. how some devices mimic, improve and replace aspects of human communication system, including analogue and digital formats
3. the properties of electricity, sound waves and electromagnetic radiation and how these are used to transfer energy in the context of communication systems
4. different forms of energy and their transformation and transfer during communication
5. the law of conservation of energy and concept of efficiency
6. how living organisms and manufactured devices source and use the energy they need to function
7. concept of input → processor → output applied to living organisms and devices that apply this concept
8. electrical circuits and devices for controlling the transfer of energy
9. calculations relating to energy generation and transfers, including power and efficiency
10. barriers to further extending our ability to communicate between places
11. how to collect and record accurate data.

Learners must be able to:

1. plan how to gather energy and energy transfer data
2. measure energy transfer
3. calculate efficiency of energy transfer and transformation
4. process experimental results in order to draw conclusions and suggest improvements.

In order to engage with this topic effectively, learners must use the following PLTS:

- creative thinkers
- effective participators.

Topic 2.5 Seeking natural resources (60 GLH)

Natural resources including water, biomass, minerals and fossil fuels are the starting point for manufactured materials and products, and can be valuable sources of energy. Finding economically viable resources, extracting and processing them with minimal irreversible effect on our natural environment and climate is a major task for scientists, technologists and engineers. Successful exploration and experimentation will help us to meet the demand for sustainable energy sources and chemical feedstock. Successful exploration, however, needs to take account of the cultures and economies of local communities as well as the natural environment.

The purpose of this topic is to introduce learners to the importance of the Earth's four spheres, how we explore, extract and process natural resources and the effect of our activities on these four spheres. Learners will investigate data obtained from secondary sources to gain a picture of national and global exploration. Learners will examine, analyse and test environments where natural resources are located. They will be able to use the information and data they obtain to advise on the exploration for a natural resource.

This topic links to topics 2.3 and 2.1.

Learners must know and understand:

1. the structure of the Earth and its four spheres
2. how science identifies changes to the planet and environment since the formation of the Earth due to natural and human activity
3. how to monitor changes to our environment using living and non-living indicators, including technological developments in monitoring
4. ideas about how the universe was formed have been developed and changed over time by applying and testing scientific theories
5. how natural resources were formed, how they are obtained from the Earth and the implications for the environment, including the concept of sustainability
6. techniques used in the exploration and extraction of natural resources
7. how natural resources are processed to make raw materials for industry
8. the economic and environmental consequences of extraction, industrial processing and other human activity on the availability of natural resources
9. the information and data used to determine where natural resources can be found and used to test ideas

10. where exploration of natural resources does or might take place.

Learners must be able to:

1. interpret data and information on the location and scale of natural resources
2. use evidence from data and information to test an idea
3. present advice
4. examine environments for the abundance of natural resources
5. monitor changes to the environment using living and non living indicators.

In order to engage with this topic effectively, learners must use the following PLTS:

- independent enquirers
- self-managers.

Topic 2.6 Developing analytical skills (60 GLH)

The protection of consumers from unrealistic claims, testing athletes for substance abuse and monitoring the environment all depend on the application of analytical skills. Analytical scientists also make contributions in museums, art galleries and archaeological expeditions. Some of the features that characterise their work, such as challenging assumptions, attention to detail and methodical approaches, are important transferable skills, applicable in all aspects of life and work.

The purpose of this topic is to evaluate claims made for products and processes. Learners will learn how to break a problem down into a series of testable questions. They will plan and carry out safe experiments to answer these questions and test the validity of claims. They will learn to present their findings using scientific conventions and formats, analyse and evaluate data and draw evidenced conclusions. They will have the opportunity to take part in a peer review and understand the importance of peer review in evaluating these conclusions and the validity and reliability of supporting evidence.

Learners can use the contexts of topics 2.1 to 2.5 to inform their choice of the products, processes or ideas they evaluate.

Learners must know and understand:

1. the range of services provided by analytical scientists and the transferable skills they use
2. how to identify hazards in working environments and measures to minimise risk
3. how to design analytical investigations
4. techniques for scientific investigations in the laboratory and the field, including resources needed
5. standard operating procedures and protocols for laboratory and fieldwork including those used in calibration, testing and sample collection
6. techniques for biological, chemical and physical analyses (qualitative and quantitative) and their applications
7. techniques for calibrating and testing analytical glassware and measuring equipment
8. scientific principles upon which analytical techniques are based
9. applications, operation and limitations of equipment for observing and measuring

10. techniques for analysing and presenting data and their validity
11. ways that the science community communicates with each other
12. how peer review is conducted.

Learners must be able to:

1. use good laboratory practice (GLP) in the context of analytical investigations
2. plan analytical investigations
3. conduct analytical investigations
4. communicate conclusions
5. review processes and conclusions made by others
6. provide constructive feedback.

In order to engage with this topic effectively, learners must use the following PLTS:

- independent enquirers
- creative thinkers
- reflective learners.

Topic 2.7 Developing scientific ideas (60 GLH)

Scientific knowledge and the ability to apply it moves forward when scientists take what they already know and test it out in new contexts, for example in the development of new drugs, the production of new materials or the invention of new processes. Coming up with ideas for change and development requires some capacity for thinking beyond what is familiar and is also supported by drawing on the knowledge and experience of others. The decision to take an idea forward to develop a new product, process or service will depend upon a thorough understanding of the resources required and the possibilities of success.

The purpose of this topic is for learners to work with others to develop and explore ideas. Learners will be introduced to the processes involved in taking ideas and applying them in real contexts. Their idea can be drawn from the areas of science studied in topics 2.1 to 2.5. Based on their investigation of the potential application of their idea, they will be able to communicate their proposal to others.

Learners must know and understand:

1. how scientific ideas have developed through history, including conceptual breakthroughs and application breakthroughs; serendipitous discoveries and planned discoveries
2. the stages involved in turning concepts into products, processes and services including research and development, prototype, testing, development of a specification
3. there are some questions that science cannot currently answer and some that science cannot address
4. the demand-led and supply-led nature of scientific development
5. any contemporary scientific development will have benefits, drawbacks and risks
6. successful commercial products that were based on innovative science and reasons for their success
7. the innovation cycle
8. the contribution of science to local and national economies
9. how scientific research and development is funded
10. how decisions about the applications of scientific ideas are made including taking into account the attendant economic, social and ethical issues

11. the legal environment affecting the development and introduction of products, processes and services, including intellectual property and its legal protection
12. how teams are established and operate to tackle scientific problems.

Learners must be able to:

1. collaborate with team members
2. present information to different audiences
3. substantiate findings
4. develop scientific ideas.

In order to engage with this topic effectively, learners must use the following PLTS:

- independent enquirers
- creative thinkers
- team workers
- effective participators.

Personal, learning and thinking skills

Awarding organisations must design learning outcomes and assessment criteria that clearly include opportunities for the development of PLTS. At all levels of the Diploma, principal learning must include all six PLTS. These should be integrated as a minimum within the assessment criteria for principal learning to explicitly recognise the application of these skills within sector-relevant contexts.

Awarding organisations must also provide a clear mapping of the coverage PLTS within their submission. This should be at the level requested under each topic within the criteria, such as ‘independent enquirers’, ‘creative thinkers’, and so on.

Functional skills

Components and qualifications based on these criteria must provide opportunities for learners to develop and apply functional skills within sector-specific contexts. Awarding organisations must provide a summary of the appropriate opportunities identified.

Additional and specialist learning

Please refer to the Ofqual document *Criteria for accreditation of Foundation, Higher and Advanced Diploma qualifications* (Ofqual/08/3990) at www.ofqual.gov.uk/files/OAC_diplomas_v2.pdf for the rules governing additional and specialist learning.

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Office of the Qualifications and Examinations Regulator
Spring Place
Coventry Business Park
Herald Avenue
Coventry CV5 6UB

Telephone 0300 303 3344
Textphone 0300 303 3345
Helpline 0300 303 3346

www.ofqual.gov.uk