Qualifications and Curriculum Authority

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

Principal learning

Consultation version

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Contents

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 http://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 (DDP) 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 bodies will develop their principal learning qualifications for the Diploma.

[1] Principal learning is taken at level 1 for foundation Diplomas, level 2 for higher Diplomas and level 3 for advanced 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 introduce learners to 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:

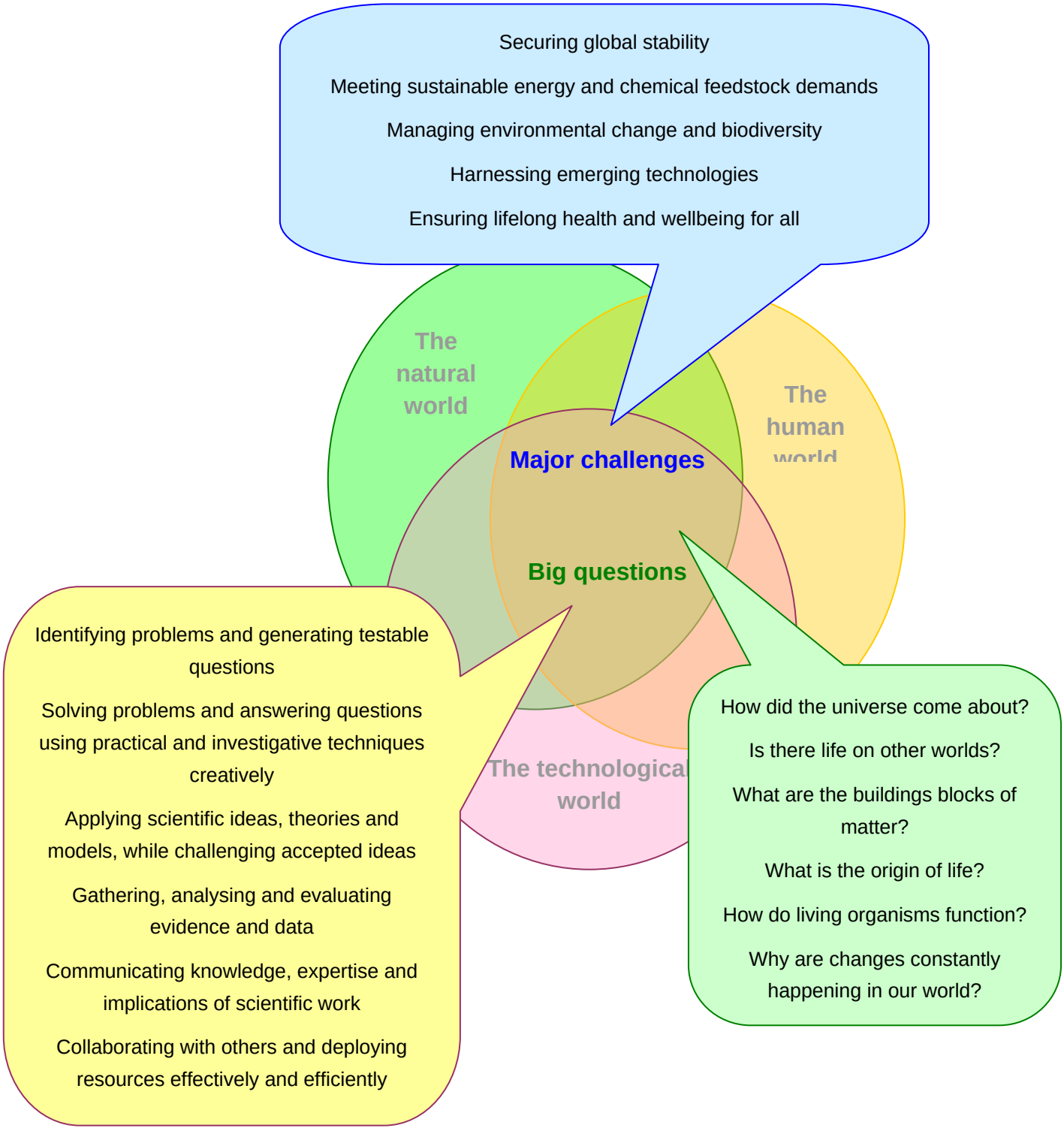
- enable individuals to acquire relevant personal, learning and thinking skills (PLTS) in a science context
- give opportunities to practise and acquire essential functional skills in English, mathematics and information and communication technology (ICT), which are relevant to the level and delivered in the context of science
- offer progression to other Diplomas, to transfer laterally and progress to further education, apprenticeships and training
- 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

The Diploma in science will offer learners a unique experience in which they gain an insight into the world of science, how science is practised and its impact on society and the world in which we live.

We live and work in three interlocking worlds: the natural world, the human world and the technological world. At the centre are major challenges for science and big

science questions. The Diploma in science confronts learners with these challenges and questions.



Over time the major challenges and the precise nature of questions change. Nevertheless, the idea that we are preparing learners for a world in which there will

always be major challenges and big questions is central to the vision of the Diploma in science. Together, challenges and questions provide a powerful tool for demonstrating the scope of scientific activity, from innovation to development, with respect to improving quality and in the investigation of natural behaviour, processes and phenomena.

The Diploma in science aims to:

- provide a hands-on approach to acquiring scientific skills and knowledge, illustrating the benefits of scientific methods and their broader application to problem solving
- develop an enthusiasm for learning about science and an understanding of how that learning can be translated effectively into marketable, practical and intellectual scientific skills
- raise learners' awareness of the impact of science on society, now and for future generations, and of the contributions they can make to scientific endeavour in the future.
- engage and enthuse learners, extend their knowledge, understanding and capabilities, and raise their aspirations and ambitions
- provide an insight into 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
- provide a solid base of scientific knowledge and methodology
- demonstrate the importance of scientific and mathematical knowledge to the process of scientific enquiry and providing answers to problems
- demonstrate how people use science (including investigating natural behaviour, processes and phenomena; innovation and development; improving the quality of life now and for generations), the environment/sector in which they work and the ways they set about their work
- provide insight into the application of science to real-life issues, including those relevant to learners' lives
- enable learners to understand the significance of scientific problem-solving methods as useful life skills
- emphasise the importance of being able to transfer skills, knowledge and understanding learned in one context to new situations
- demonstrate the role of information and communications technology in the

advancement of modern science

- enable learners to find out about career pathways in the science sector, and the huge number of opportunities which become available by studying science.

This line of learning criteria (LoLC) has been organised into topics that show how different scientific disciplines such as biology, chemistry and physics contribute in different, but overlapping, ways. It attempts to show learners how scientific knowledge and expertise is deployed within and across disciplinary boundaries to solve the most complex questions and challenges that confront us.

At each level, the LoLC has organised content into seven topics. Five topics are centred around domains of science. In these, learners develop knowledge and understanding of the core underlying principles and concepts of science whilst following standard procedures and protocols. The content of these topics has been carefully considered to allow learners time to develop practical skills, applying their knowledge and understanding to different contexts and situations through purposeful activities. Two topics at each level will draw on the contexts of the first five topics, but allow learners to operate more independently and develop their own approaches to dealing with problems. At level 1, these topics are set within a defined context that would be familiar, engaging and accessible to the learner. To provide the level of demand appropriate to level 2, there are no pre-determined contexts, allowing learners to expand the range of contexts and situations in which they can apply their knowledge, understanding and skills.

Principal learning puts the acquisition of practical scientific and mathematical skills at the core of learning, enabling the maximisation of enquiry and problem-based learning. Practical skills will include handling materials, apparatus and equipment. They go hand in hand with the higher-order thinking skills that lie behind rigorous scientific methods such as experiment design and critical evaluation of data. Mathematical skills will be developed through the units of learning where they are explicitly stated at each level of the diploma. This approach will enhance knowledge, understanding and uses of mathematics in such areas as analysis and evaluation of numerical data using statistics and estimating uncertainty.

To meet this vision all specifications must:

- have units that demonstrate the multidisciplinary nature of science
- have units with an applied purpose where learners draw on the knowledge, skills and understanding developed
- allow time for the development of practical skills and for the application of knowledge and understanding in different situations and contexts

- have units where either practical skills are explicitly assessed or where learners are able to draw upon their practical experiences to propose solutions to problems or to meet an applied purpose

- integrate the development of mathematical knowledge, understanding and skills in units where they are most appropriate to the scientific concepts presented.

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 KS4. Learners taking the diploma will also have the opportunity to apply key concepts and processes from the KS4 programme of study for mathematics in a range of scientific contexts which will help support and strengthen their knowledge and understanding of mathematics.

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 KS4 through the statutory programmes of study, and entitlement areas. The aim of this guidance is to support consortia to design coherent learning experience for each young person on their Diploma programme.

Diversity and inclusion

Diplomas will enable all learners to be assessed by means of internal and external assessment, differentiating only on the basis of candidates' 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.

Component awarding bodies 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 bodies 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 candidate's usual methods of working and not invalidate the competency standard of the assessment requirements.

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

To support the requirements above, component awarding bodies 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 candidates 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

The six areas of diversity in law are disability, gender, race, age, sexual orientation and religion/belief. In addition, Ofqual's regulation promotes equality and aims to eliminate discrimination in terms of disability, gender and race, in accordance with public sector equality duties.

Themes

The classification of topics under themes has not been specified by the Diploma in science DDP.

Structure

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

Principal learning level 1: Summary of topic titles

Topic no.	Title	GLH
1.1	Making useful substances	30
1.2	The condition of the human body	30
1.3	Planning for the growth of plants and animals	30
1.4	Energy sources for home technologies	30
1.5	Our changing world	30
1.6	The contribution of science to society	30
1.7	Developing and testing scientific ideas	60

Topic 1.1 Making useful substances (30 GLH)

The Earth's crust is a vital but finite resource of raw materials used by industry. Knowledge gained by analysing and obtaining materials can be used to contribute towards meeting the challenges of securing global stability and meeting sustainable energy demands. Organisations and people that contribute to the analysis, preparation and separation of materials include exploration, extraction and chemical industries, chemists and geologists.

This topic will consider substances in the context of consumer products, including natural and synthetic materials. Through a practical approach, learners will find out how to separate mixtures, purify chemical substances and prepare mixtures of known composition. With this, they will be able to make a substance for a purpose.

Learners must know and understand:

1. the simple particle model of states of matter
2. natural materials and synthetic materials used in consumer products and how they contribute to their purpose
3. the pure substances or mixtures that can be found in materials
4. the concept of reversible and non-reversible changes and chemical change
5. word equations and simple balanced symbol equations
6. how to separate mixtures and obtain pure substances
7. how to interpret consumer information on consumer products
8. how to prepare chemical substances.

Learners must be able to:

1. interpret word equations and simple balanced symbol equations to produce useful substances
2. use separation techniques
3. prepare substances for specific applications.

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

- independent enquirers.

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

The health and wellbeing of the human body is influenced by many factors, including the lifestyle choices of the individual. Many types of organisation and people are involved in identifying how different lifestyle choices affect the human body at different life stages, how positive lifestyle choices are promoted and how the negative effects are managed. These include clinics, rehabilitation units, sports centres, dieticians and nurses. If the major challenge of maintaining health and wellbeing is to be achieved, greater awareness of the consequences of lifestyle choices on the individual and society is needed.

The purpose of this topic is to enable learners to build on their knowledge of the structure of the human body, from cells to organ systems, and how it functions. They will consider how lifestyle affects the body's functions at different life stages, from young children to elderly people. They will learn to obtain information from people at different life stages and to use this information, together with baseline data, to determine the likely effects of their lifestyle on their body. As a result, learners will be able to advise individuals at different life stages of these likely effects.

Learners must know and understand:

1. the structure and functioning of the human body, including how a steady state is maintained

2. how the structure and function of the human body change at different life stages

3. baseline measurements of vital signs and the condition of the human body, including body mass index (BMI) and ways in which they are determined, including observation, samples for analysis and the types of equipment used

4. positive and negative lifestyle choices, including diet, drugs, exercise and sexual activity

5. the effects of lifestyle choices on how the body functions and the implications for the health of the individual and society

6. the relationship between reproduction, inheritance, development and lifestyle

7. the 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

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

9. how to communicate with individuals at different life stages.

Learners must be able to:

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

2. interpret data on the condition of the human body

3. seek assistance when required.

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

- effective participators
- self-managers.

Topic 1.3 Planning for the growth of plants and animals (30 GLH)

We depend on our ability to propagate and grow plants and breed animals efficiently to obtain products such as food, clothing and fuel. Plants and animals can be used to contribute to providing adequate food and water supplies and meeting sustainable energy and chemical feedstock demands. It has the potential to help meet sustainable energy and chemical feedstock demands. People who tend plants and animals include farmers, horticulturalists and animal technicians. They apply scientific knowledge and understanding to the cultivation of plants and animals as sources of useful products.

Through practical hands-on experiences, learners will find out about key factors that affect the successful tending of plants and animals, and scientific methods to monitor their health and growth, including associated ethical issues. They will learn to test if the conditions needed to grow plants and animals exist in an environment. As a result, they will be able to draw on their practical experiences of tending plants and animals to plan their growth within specified environments.

Learners must know and understand:

1. the ways in which plants and animals could be used and processed to contribute to providing adequate food and water supplies and meeting sustainable energy and chemical feedstock demands
2. plant propagation and cultivation methods, and animal breeding and nurturing techniques, including natural and artificial selection
3. the conditions needed for healthy growth of plants and animals, including physical conditions and soil and water quality
4. how to monitor the growth of plants and animals
5. signs of health and disease in plants and animals
6. how to obtain data on the conditions of a local environment, including soil and water
7. how to calculate growth rate
8. the standard protocols used to record growth rate
9. the resources required to grow plants and animals, including time, costs, supplies and environment
10. the ethical considerations of using and handling plants and animals
11. how to present data in diagrammatic form.

Learners must be able to:

1. test soil and water
2. record growth data
3. calculate growth rate
4. monitor the growth of plants and animals
5. use experiences of growing plants and animals to inform future plans
6. present data on the conditions of a local environment
7. plan the growth of plants and animals.

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

- independent enquirers
- self-managers
- reflective learners.

Topic 1.4 Energy sources for home technologies (30 GLH)

Around the world, people depend on sustainable supplies of reliable energy resources. Solutions are urgently being sought to the problem of our overdependence on fossil fuels. Biochemists, chemists, engineers and nuclear physicists are all contributing to the development and application of home technologies.

The purpose of this topic is to allow learners to explore the potential for reducing reliance on fossil fuels for electricity generation in the context of home technologies such as hair straighteners, home entertainment systems and portable appliances. Many of these run on mains electricity, others use batteries, gases and other sources of energy. Learners will carry out tests to determine the usefulness of different sources of energy to power home technologies in order to recommend appropriate energy sources.

Learners must know and understand:

1. the present energy sources used with home technologies
2. the ways in which energy sources could be used with home technologies
3. the impact of energy sources on the environment, including their extraction, manufacture and waste
4. the types of energy, including heat, sound, light, chemical, electrical and kinetic
5. the ways in which energy is transferred from place to place
6. the transformation of electrical energy into other forms of energy, including kinetic, sound, heat and light
7. the methods of investigating the transformation of energy, including the idea of useful energy, waste energy produced by an electrical device
8. the relationship between energy and power
9. the power consumption of home technology appliances
10. how to calculate efficiency of transformation of energy
11. the ways in which waste heat energy can be reduced and recycled.

Learners must be able to:

1. interpret data on the environmental effects of using different energy sources

2. set up experiments

3. use equipment in experiments

4. estimate waste heat produced by home technologies

5. calculate the efficiency of energy transfer.

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

- creative thinkers
- reflective learners.

Topic 1.5 Our changing world (30 GLH)

Many scientists work on fundamental questions about how the world we live in has developed in the way it has. Has change been caused by natural events such as volcanic eruptions and forest fires or by human activity such as burning fossil fuels? Through reliable monitoring of the environment, scientists are able to determine the cause of change.

This topic will introduce learners to some of the possible causes of environmental change, including natural events such as volcanic eruptions and forest fires, and human activity such as draining land for cultivation. They will have the opportunity to test an environment for evidence of change and research the potential causes of change. They will explore conflicting arguments and use secondary sources of information to judge the validity of the arguments. Learners will be able to use primary and secondary data to argue whether an idea relating to change in an environment is right or wrong.

Learners must know and understand:

1. natural and synthetic causes of environmental change
2. how environmental change is manifested in an environment
3. the nature of the Earth's four spheres
4. the Earth's position and movement in the solar system and the impact of the moon's gravity
5. weather patterns and climate and their relationship to the atmosphere, sun and the solar system
6. how pollution and waste are monitored and controlled
7. methods for testing for pollution in an environment
8. how to judge the validity of information and data
9. how to present an argument, including the use of models.

Learners must be able to:

1. test for environmental change
2. present an argument
3. use ICT simulation software.

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

- independent enquirers
- creative thinkers
- effective participators.

Topic 1.6 The contribution of science to society (30 GLH)

Whether in health, technology, environment, consumer products or other contexts, scientists are working to meet major challenges and improve on or inform the quality and sustainability of life. These scientists may work in diverse fields, locations, work environments and organisations. As well as supporting the quality of life, these scientists are also potential role models to learners, demonstrating the job roles and career opportunities to which they can aspire.

This topic provides learners with the opportunity to visit the workplaces of scientists and explore with them the nature of the work that they do. These opportunities would be within specific science disciplines and fields of work. Learners will use primary research to consider the economic, social or environmental contribution that the work of these scientists can provide. Linking to the knowledge of science domains gained in topics 1.1 to 1.5, learners will be able to explore the work of scientists and consider those areas that excite them. They will explore their own ideals, their attitudes to science, the ethical issues that some of the work of scientists present and the contribution they consider is the most important. As a result, they will be able to set their own criteria for what would make a good career goal.

Learners must know and understand:

1. the 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 contribution of technology to the science used by these organisations and agencies
4. the people in the organisations and agencies that use science
5. how individuals establish values, including consideration of ideals, attitudes, beliefs and priorities, and how these can affect an individual’s decisions and actions
6. why organisations and agencies that use science weigh the benefits against potentially controversial aspects of their work
7. the techniques of primary research to obtain qualitative information
8. the use of ICT to analyse and present findings.

Learners must be able to:

1. set themselves challenging goals with success criteria

2. acknowledge values of self and others

3. conduct primary research

4. use ICT software to analyse and present findings.

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

- independent enquirers
- reflective learners.

Topic 1.7 Developing and 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 for the advancement of science with no planned application. All scientists start with ideas that need to be tested: Are they valid? Will they work? This is critical in commercial environments, 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. Topics 1.1 to 1.5 should provide the contexts on which these products and problems are based. 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.

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 provide constructive support and feedback
4. the process involved in product development, including research and development, prototype, testing and development of specification
5. products that have been developed with scientific input and the science that was used
6. how the ideas behind products were developed
7. the multidisciplinary nature of the science input used in the development of products
8. the value of science to product development
9. the types of tests that can be used to test the feasibility of an idea
10. the health and safety issues associated with conducting tests.

Learners must be able to:

1. design tests
2. collaborate with others towards common goals

3. generate ideas
4. organise resources
5. conduct fair tests
6. manage time
7. refine an idea.

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

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

Principal learning level 2: Summary of topic titles

Topic no.	Title	GLH
2.1	Analysing substances for a purpose	60
2.2	Improving the performance of the human body	60
2.3	Maximising the yield of plants and animals	60
2.4	Sustainable energy use	60
2.5	Seeking natural resources	60
2.6	Adapting standard procedures and protocols	60
2.7	Developing a product specification	60

Topic 2.1 Analysing substances for a purpose (60 GLH)

Converting raw materials obtained from the Earth's crust, waters and atmosphere into more useful products is a vital area of scientific activity. Medicines, fertilisers, cosmetics and fuels are just some examples of these products and these help to improve our health and wellbeing. Organisations and people contributing include materials-testing and public analyst laboratories, chemical plants, chemists and laboratory technicians.

The purpose of this topic is to introduce learners to the preparation and analysis of compounds, mixtures and other materials, together with an understanding of their structure and bonding, and the physical and chemical changes involved in the preparation and analysis. Learners will have opportunities to prepare and analyse compounds, mixtures and other materials. Learners will be able to draw on their practical experience and understanding to analyse substances to determine if they are fit for purpose.

Learners must know and understand:

1. useful materials made from substances and the purposes they serve
2. the performance characteristics of substances and how they are determined
3. techniques for preparing compounds and calculate yields
4. how to make solutions of known concentration and other mixtures
5. techniques for obtaining, making or modifying materials
6. how to determine the physical properties of materials
7. how to determine the purity of compounds and the composition of mixtures
8. the types of physical and chemical changes and how particle models may be used to describe them
9. the structure and properties of atoms and their combination in compounds and materials with different properties
10. chemical formulae, balanced symbol equations and displayed chemical formulae
11. the consequences of not following standard procedures and protocols.

Learners must be able to:

1. analyse substances

2. measure quantities

3. record data

4. use chemical formulae in calculations

5. determine the effect of not following a given standard procedure.

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

- self-managers
- reflective learners.

Topic 2.2 Improving the performance of the human body (60 GLH)

The human body is a complex and sophisticated organism. The ability to assess the wellbeing of the human body, to measure how effectively the body is functioning and to identify improvements which could be made is crucial in many occupational roles such as doctors, occupational therapists, physiotherapists, dieticians and sports scientists. An understanding of how the wellbeing and fitness of the human body can be maintained and improved can also be applied by any individual reflecting on their own health and wellbeing.

The purpose of this topic is to allow the learner to develop an understanding of the factors that affect the functioning of the human body and how science can be applied to help improve health and wellbeing. Learners will consider individuals with different roles such as construction worker, office worker or elite athlete. They will be able to plan programmes for improving the performance of the human body, taking account of the role of the individual.

Learners must know and understand:

1. appropriate ways in which the condition of the human body can be monitored for individuals in different roles
2. the range of normal values for vital signs of individuals with different roles
3. the cardiovascular and respiratory systems
4. the musculoskeletal system and biomechanics
5. the methods and equipment used to measure the effect of the performance of individuals in different roles on the functioning of the human body
6. the mathematical equations and diagrams used to describe biomechanics relating to mass, velocity, work done, forces, acceleration and energy
7. the types of exercise that can be used to improve the physical condition of the human body
8. the resources used to improve the condition of the human body, including the use of technology and resources available in the home or workplace
9. how diet affects performance of the human body.

Learners must be able to:

1. plan programmes for improving the condition of the human body
2. measure indicators of wellbeing, including movement, strength and BMI

3. record data about the human body

4. interpret data about the human body

5. present information about the human body, including the use of mathematical equations.

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

- creative thinkers
- effective participators.

Topic 2.3 Maximising the yield of plants and animals (60 GLH)

Plants and animals are vital resources from which we are able to obtain useful products such as clothing, drugs and construction materials. Nurturing these organisms helps meet the challenges of providing adequate food supplies worldwide and ensuring lifelong health and wellbeing for all. It is essential, therefore, that science can assist in developing an understanding of the needs of plants and animals so that productivity can be increased. Improvements to productivity may also be secured through developing specific characteristics of plants and animals over time.

The purpose of this topic is to introduce learners to the conditions required for the growth of plants and animals, and the techniques which are used to monitor growth. It also allows them to explore how characteristics are determined by inheritance and how this can be used to select and breed for specific useful characteristics. Through this topic learners will be able to propose programmes which maximise the yield of plants and animals to meet specified needs.

Learners must know and understand:

1. the ways in which plants and animals are used for essential products for the benefit of human beings, including in less economically developed and more economically developed countries

2. why it is important to optimise yield of plants and animals in meeting major challenges

3. the concepts of adaptation, competition and evolution

4. the principles of genetics

5. the roles of biological compounds in plants and animals and their dependence on the availability of specific elements

6. the processes of photosynthesis and respiration, and factors that affect the rates of these processes

7. the conditions for healthy growth and maturation of different classes of plants and animals

8. the structure of cells, how they multiply and how materials get in and out of them

9. methods to monitor health, growth and changes to plants and animals

10. methods used to breed and nurture plants and animals to promote desirable traits, including the use of growth hormones

11. techniques used to optimise yield of plants and animals

12. the legal and ethical requirements and the standard procedures and protocols in place for the use and handling of plants and animals

13. the competing requirements that need to be considered for land use.

Learners must be able to:

1. plan a programme to breed and nurture plants and animals, and to optimise growth rates

2. use instruments to monitor the health and growth of plants and animals

3. interpret growth-rate data

4. calculate probabilities using genetic data

5. use appropriate ICT to analyse and present data

6. determine yields.

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

- self-managers
- reflective learners.

Topic 2.4 Sustainable energy use (60 GLH)

We are an energy-dependent society with a duty to use resources wisely and protect them for future generations. If sources of energy are finite, we have to reduce our dependency on these sources, ensuring our energy use is sustainable. The efficient management of energy transfer makes an essential contribution towards sustainable use of energy. We can also reduce our dependency by changing the way we live, for example using less packaging or reducing car ownership. An understanding of the fundamental principles of the conservation of energy and how energy is changed from one form to another underpins the work in many occupations, including physicists and engineers but also those working in transport, building and sports science. In all these occupations the need to use and store energy as efficiently as possible is critical.

The purpose of this topic is to consider how energy may be harnessed, stored and transferred. Through practical work, learners will explore mechanical and electrical devices that change energy from one form to another. They will explore how these processes can be measured, including their efficiency and the practical methods that are used to improve efficiency. Learners will be able to draw on their practical experiences in order to promote ways of reducing energy use.

Learners must know and understand:

1. the scientific notation, units, symbols and formulae associated with energy and power

2. ways of reducing energy use and dependency on finite resources as energy sources

3. the need to harness sustainable energy sources, store the energy obtained and use it efficiently

4. the storage, transfer and transformation of energy and the principle of energy conservation

5. the energy changes associated with moving objects and how to represent them using graphs and diagrams

6. calculations associated with movement

7. the mechanical and electrical devices used to transform energy from one form to another and the concept of efficiency

8. how to estimate the efficiency of devices for transforming energy

9. how to carry out calculations concerned with work done, changes in potential energy, kinetic energy and power

10. how types of insulation can affect energy consumption and how to calculate the amount of heat energy transferred when an object changes temperature

11. the methods used by the private and public sectors to promote change in society.

Learners must be able to:

1. measure energy transfer

2. record data effectively

3. plan how to gather energy and energy transfer data

4. promote solutions to energy problems.

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

- creative thinkers
- independent enquirers
- reflective learners.

Topic 2.5 Seeking natural resources (60 GLH)

Natural resources include biomass, ores, minerals and fossil fuels. They are the starting point for all manufactured materials and products. Finding economically viable resources, extracting them and processing them with minimum effect on our natural environment and climate is a major task for scientists, technologists and engineers. Successful investigation will help us to meet the demand for sustainable energy and chemical feedstock. Oil and mineral exploration companies, agriculturalists, geoscientists and others play their part.

The purpose of this topic is to introduce learners to the importance of the Earth's four spheres and how we explore, extract and process natural resources. 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.

Learners must know and understand:

1. the structure of the Earth, its four spheres and its position and movement in the solar system
2. the origin of seasons and weather and their influence on the environment
3. changes to the environment due to natural and human activity
4. how to maintain biodiversity and monitor changes to our environment
5. how natural resources for industry are obtained from the Earth and implications for the environment
6. the techniques used in the exploration and extraction of natural resources, including wave energy
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
10. where exploration of natural resources is taking place, including on other planets.

Learners must be able to:

1. interpret data and information on the location of natural resources
2. present advice
3. test environments for the existence of natural resources.

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

- independent enquirers
- self-managers.

Topic 2.6 Adapting standard procedures and protocols (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 purpose of this topic is to enable learners to consider the standard procedures and protocols used when undertaking scientific tasks and how they are founded on good laboratory practice. Topics 2.1 to 2.5 will provide the contexts in which learners will consider the types of activities of scientists and the standard procedures and protocols they use. Learners will be able to use practical experience to adapt standard procedures and protocols to respond to changes in requirements.

Learners must know and understand:

1. the timescales involved in undertaking scientific tasks
2. how to identify hazards in working environments
3. the requirements of a risk assessment
4. measures to minimise risk
5. how to design experiments for optimum results
6. the principles of good scientific investigation in the laboratory and the field
7. the standard protocols for laboratory and fieldwork
8. the limitations of equipment used for observations and measurements and how this affects confidence in data gathered and minimise limitations
9. methods used to analyse and interpret evidence and data, including identifying possible sources of data error.

Learners must be able to:

1. adapt standard protocols
2. identify hazards
3. use good laboratory practice (GLP)
4. propose measures to minimise risk of hazards

5. select resources needed to complete a project.

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

- creative thinkers
- effective participators
- reflective learners.

Topic 2.7 Developing a product specification (60 GLH)

Science makes contributions to local and national economies. Inward investment is received from funding sources for research. Commercial organisations receive revenues from the sale of their scientific ideas and products. This, in turn, provides employment for scientists and others that use science such as engineers, construction workers and farmers. Whilst the scientist might develop an idea that could be turned into a commercially viable product, it is the marketing and financial functions of a business that decide whether or not that product can be taken to market.

This topic introduces learners to the processes involved in developing ideas into commercially viable products. They will have the opportunity to develop an idea related to the science studied in topics 2.1 to 2.5 into a prototype and will also learn about the business functions involved in determining the commercial viability of a product. Learners will be able to recommend a product specification for a product that will be commercially viable.

Learners must know and understand:

1. the contribution of science to the national economy
2. the sources of funding for scientific research and activity, including government and European Union (EU) grants, private initiatives, charitable donations and commercial revenues
3. how teams are established and operate to tackle scientific problems
4. successful commercial products that were based on innovative science and reasons for their success
5. the stages involved in turning a concept into a commercial product, including research and development, prototype, testing and development of a specification
6. the marketing and financial functions of a business and their role in product development
7. the demand-led and supply-led nature of scientific development
8. the legal environment affecting the development and introduction of a product, including intellectual property and its legal protection
9. the factors affecting the success of the introduction of a new product
10. the use of product briefs to develop a prototype
11. methods for testing a prototype

12. the purpose and content of a product specification

13. how prototypes are adapted into a product specification, including consideration of industry standards, quantity of production, health and safety issues, operating environment, maintenance requirements and end of life disposal.

Learners must be able to:

1. recommend a product specification

2. collaborate with team members

3. conduct market research

4. analyse and present data

5. substantiate findings

6. develop a prototype.

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

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

Personal, learning and thinking skills

Awarding bodies 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 bodies must also provide a clear mapping of the coverage of 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 bodies 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 http://www.ofqual.gov.uk/files/OAC_diplomas_v2.pdf for the rules governing additional and specialist learning.

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The following text will appear here following subsequent approval of the LoL Criteria by OfQual in July 2009.

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