Science and Technology AoLE:

Submission to Curriculum & Assessment Group: December 2017

(Revised following CAG feedback during AoLE workshop 12-13 December 2017)

Table of Contents

Introduction

In July 2017 Welsh Government published an update outlining an approach to curriculum development and sharing early thinking about the Areas of Learning and Experience (AoLEs) outlined in *Successful Futures*. This January update describes the next stage of the development process - the identification of 'what matters' within the six AoLEs.

The 'what matters' approach is the identification of the key elements that all learners should experience during their journey along the continuum of learning. The four purposes of the new curriculum are at the heart of all discussions relating to this work.

Each AoLE will contain of a series of 'what matters' statements. In developing these statements, the Pioneers have conducted extensive research and invited experts to make presentations and join debates with their groups.

This approach has been endorsed by Professor Donaldson and other leading academics. A combination of commissioned academic papers and secondary academic research has also confirmed the belief amongst Pioneers and advisory groups that this is the right approach for Wales to take in curriculum development.

The papers contain the initial drafts of 'what matters' statements with supporting rationale, to provide a basis for sharing and discussion. They reflect the AoLE groups' thinking in December 2017. As part of an iterative process the AoLE groups will continue to refine the 'what matters' statements, in parallel with work to develop the underpinning progression frameworks, and the detail of the AoLEs.

As the work progresses, a newly established Coherence Group, chaired by Professor Richard Daugherty, will ensure consistency and coherence across the curriculum. The group will evolve to become a Manageability group to provide critical challenge about the size of the curriculum and how it is to be delivered, as more detail becomes available.

Outline of approaches taken during the Autumn term 2017

During the autumn term the AoLE working group (the Group) has conducted further research and consideration of 'what matters' for science and technology. Those research resources utilised by the group since September, which include some specific commissions, are listed in the bibliography.

To ensure conformity and consistency pan-AoLE on the development of what matters statements, the group utilised the principles contained in a paper by Barbara Wintersgill (Wintersgill, 2017).

The group met for two-day workshops on four occasions this Autumn producing several draft sets of what matters statements, further refined as part of Group tasks in-between whole Group meetings, and shaped into a single set of initial draft 'what matters' statements at the November meeting.

As part of the development process, the Group undertook a series of three Task and Finish sessions in September / October looking separately at science, computing, and design / technology, with expert advisory inputs at each. Pioneers elected to attend the Task and Finish session most appropriate to their specific interests. The Group also organised 'regional cluster' meetings of Pioneers between working group meetings to better facilitate joint working on tasks.

At the full AoLE workshop in November, the Group considered all the content and advice presented from homework sessions and the Task and Finish meetings. Expert advisory input was also organised for the full two days, with representation from each of the subject domains with this AoLE. A list of external experts is contained at Appendix A. Following the November workshop, the Group further refined thinking in regional cluster sessions; the output from which was presented for consideration by the Curriculum and Assessment Group (CAG). The Group updated their working hypothesises for the what matters statements following CAG feedback, at the December Group meeting.

In total therefore, the process during the Autumn term accounted for 8 full days of workshop activity, 3 full days of domain specific considerations, and 12 Pioneer regional cluster sessions between the working group meetings.

The Group has called for stronger secondary Pioneer representation for physics, biology and chemistry as it continues to struggle with a balance of expertise and perspectives in this area. Consortia have been supportive of this, and the Group's capacity will be boosted as the statements are further refined, and work on progression starts in 2018.

1. A statement defining 'what matters' in the context of the AoLE

Through understanding ‘what matters’ about science and technology, learners will develop a solid understanding of the world around them to allow them to become confident, capable, creative citizens.

By taking account of the health and well-being of themselves and others, considering all evidence including critically analysing data or outcomes, learners make informed decisions, which develop them into healthy and confident individuals.

Scientific and technological issues are settled by ethical and informed citizens who evaluate and consider the overall strength of the evidence, combined with rational, moral, consistent and objective argument.

Science and technology endeavours to prove, disprove or achieve through innovation, prediction, testing and questioning enterprising, creative contributors. They will understand that if a repeatable observation, prototype or an experimental result does not support an idea or specification, then the idea has to be rejected or modified and then tested again in an iterative process.

Science and technology is dynamic. Ambitious and capable learners understand knowledge is always subject to challenge from new evidence, new and emerging technologies, and must accommodate whatever innovations in science and technology thinking and understanding that may arise in the future. They embrace challenge and generate solutions that may not be immediately obvious or within their current realm of understanding. They take risks, innovate and evaluate with resilience and purpose whilst both problem finding and problem solving to improve the everyday lives of themselves, people in their local community and the wider world.

2. Initial titles for 'what matters' in Science and Technology

Rationale and other considerations

The identification of ‘what matters’ statements has involved extensive research and debate, with the Group testing various approaches to capturing ‘what matters’ in science and technology, before developing a preferred approach. The Group has decided to further develop and refine statements which capture the key fundamentals of the sciences, computing, and design and technology disciplines; while also developing interdisciplinary statements to better represent those areas that matter which embrace elements more widely across the AoLE.

The Group discussed the distinction between big ideas, what matters and key concepts at length. There was also detailed and constructive debate on how subject domains are represented through the statements, and in particular how increasing levels of sophistication in understanding are expressed and ensured so that learners are best prepared for progression in related area of study beyond compulsory education. The Group concluded this needs to be explored in greater depth as part of the work on progression in 2018. The Group is of the view that the draft statements will need further refinement and, no doubt, amendment as understanding of progression within each statement evolves. They, nevertheless, provide a sound basis as a means of expressing the essence of the AoLE to enable that further work to take place in 2018.

The Group is also keen to explore further the dependencies, and potential overlaps with other AoLEs over the coming period, leaning on the work and guidance of the Coherence Group in this regard. Some initial discussions between Pioneers have already taken place between Pioneers within the Group and those from the Health and Wellbeing AoLE working group. There are, however, relationships between this AoLE and all the others which need to be considered in greater depth.

The Group recognises that science and technology are closely linked, each depending on the other, and the AoLE holds the potential to better capitalise on curiosity about the natural and physical world through investigating, understanding and explaining. The AoLE provides the opportunity to learn how technology and product design enables scientific and other knowledge to improve the quality of human life. It is also important as it introduces computer science for all learners, to help create economic and social advantages for all children educated in Wales.

The Group is of the view that all of the following "What Matters" statements are appropriate to be taught across the whole of the 3-16 continuum.

1. **The understanding and application of precise algorithmic processes can develop software and hardware systems and solutions**.

   Why does this matter?

   Scientific understanding of phenomena is dependent on data from which many forms of information are computed. Information is fundamental to scientific enquiry, design, how we build and manage modern society, and how we develop and behave as individuals. The rapid evolution of technology has allowed each generation to experience a transformation which improves lives and interactions as well as changed the way science is done. Computation is the application of algorithms to data. It provides the theoretical foundations for creating software and hardware systems that are bound by mathematical and physical constraints.

2. **Through the application of design knowledge, skills and materials awareness, the iterative development of appropriate and innovative technical solutions improves everyday life and extends human activity.**

   Why does this matter?

   Any design is the result of interdisciplinary and innovative thinking and knowledge. Understanding the ways in which technology and design can help us to explore our universe will lead us to further appreciation of that universe. Just as nature has adapted to the diverse needs of the world, we must place the user's needs at the centre of the iterative design process. These needs will be many and varied. The range of diverse material properties the natural world offers us helps us to meet the needs of designed and engineered world.

3. **The behaviour of the Universe at its most fundamental level, including matter, force, energy and space, as applied to both large objects and the constituents of matter.**

   Why does this matter?

   Our understanding of our place within the universe is constantly changing. The universe provides matter, forces and energy that daily routines rely on. We seek to understand what laws govern the universe, and apply these in our everyday lives. It is the underpinning knowledge to further understanding and apply it in different contexts. Curiosity has furthered our understanding, though the future of the universe is unknown. The laws of physics are universal. Objects interact with each other (by contact or at a distance) and this gives rise to pairs of forces.

4. **Organisms are living things which have diverse structures and functions, which interact with each other and their environment, evolving over time.**

Why does this matter?

Organisms are living entities which are varied. Most living things have a cellular structure and are constituted of one or more cells. Multi-cellular organisms have cells that are differentiated according to their function. Growth is the result of multiple cell divisions. Organisms require materials and energy in order to carry out the basic functions of life and to grow. Energy flows through ecosystems, in which there is competition among and within species for the energy resources and materials they need to live and reproduce. Over countless generations resulting from natural diversity within a species leads to the selection of those best suited to survive under certain conditions.

5. **Matter is made of particles, the behaviour and arrangement of which explain its properties, and which can be re-arranged to form new substances through chemical reactions.**

Why does this matter?

Atoms are the building blocks of all matter, living and non-living. The behaviour and arrangement of the atoms explains the physical and chemical properties of different materials. The properties of materials and substances will influence their use. In chemical reactions, atoms are rearranged to form new substances. The structure of atoms determines the ways in which they combine to form molecules and compounds. Understanding how substances undergo chemical reactions helps us to understand the changes we see around us, and how we can influence those changes to produce substances for particular purposes.

6. **There are ethical and ecological impacts and implications of science and technology at personal, local and global levels and beyond.**

Why does this matter?

Your future depends upon philosophical, ethical and ecological choices made when applying science and technology at an individual, local and global scale, and beyond. Science and technology can improve the quality of life through new developments and advances in emerging technologies. However, human development has caused and continues to cause some unintended consequences.

7. **Technology enables scientific enquiry, improving our understanding of the world. The application of scientific understanding can result in technological solutions, engineered systems, product innovation and design.**

Why does this matter?

Science offers solutions to solve world problems, including daily comfort, renewable energy and sustainability. Design strategies, the development of ideas, confidence to innovate, resilience and risk taking. Design thinking is in essence the application of knowledge and understanding to critically and creatively produce diverse solutions. This is achieved through the cyclic iterative design process of prototyping, testing, analysing and refining. Risk taking is valuable: successes lead to creative product development, failed risks inform the next stage of development, whilst all risk taking encourages resilience and innovation.

8. **Scientific methods, through the use of appropriate equipment, can identify patterns which allow us to form models that simulate and predict the behaviours under investigation.**

Why does this matter?

Technological process and scientific enquiry involve planning, carrying out / implementing, analysing and evaluating. In technology and computer science pupils learn to apply a systematic yet creative approach to their work. They develop an ability to take measured risk in a trial and improvement approach. There can be more than one solution to a situation. In science the scientific method allows for robust reliable data collection and critical analysis and evaluation through systematic enquiry.

3. A further developed 'what matters' statement

It is envisaged that teaching will focus strongly on developing learners' science and technology skills and subject understanding / knowledge. They should be challenged to use and extend their critical thinking skills, metacognitive approaches, practical skills, through interesting and well considered questions and tasks posed by teachers.

There are ethical and ecological impacts and implications of science and technology at personal, local and global levels and beyond

In response to inputs from curriculum and subject specialists the current wording of this statement is under review. A number of alternative suggestions currently being worked on are included below to highlight the nature of the iterative development process underpinning the "What Matters" statements.

> *There are philosophical, ethical and ecological implications of advances in science and technology at individual, local and global scales.*
>
> *Science and technology has impact in the short and long term, locally, globally and beyond.*
>
> *The future of the planet depends upon philosophical, ethical and ecological choices made when applying science and technology at an individual, local and global scale and beyond.*

Your future depends upon philosophical, ethical and ecological choices made when applying science and technology at an individual, local and global scale, and beyond. Science and technology can improve the quality of life through new developments and advances in emerging technologies. However, human development has caused and continues to cause some unintended consequences.

As the population increases, the demands on resources and space are increased. There are finite resources on Earth that need to be managed responsibly, making our environment more sustainable. New solutions need to be developed to make the best use of resources, minimising waste, impact, pollution and ensure equity and parity for all. As humans we make choices about our own health and happiness and how this affects the quality of life for others. We must critique, question, and evaluate our decisions.

Not being afraid of the fact that your findings do not reflect your expectations, and understand that you can learn from this. We need to examine how manufacturers

can push products into the market place, regardless of a need and how this combined with planned obsolescence techniques and virtual marketing can encourage a “throwaway” society and the implications of this. Product development can have varying impacts on different groups (that excludes a social group or causes offence culturally). Developing the understanding that technological products now often have a social footprint as well as an ecological one.

We need to understand and reflect on the differences between taking inspiration from the creative and intellectual work of others and appropriating that work without permission. To understand the legal and ethical debates that surround using other people’s creative work; considering other viewpoints, audiences, and the broader community when using materials belonging to others.

In summary, we must continue to ask ourselves, even if we could, should we?

Science and Technology AoLE

December 2017

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Appendix A: Expert / Advisory Input – autumn term

Name	Organisation / Role
Louise Stubberfield	Wellcome Trust – Primary Science
Prof Tom Crick	Cardiff MET / NNEST Chair / ICT Steering Group Co-Chair
Prof Faron Moller	Swansea University – Computing / NNEST
Prof John Tucker	Swansea University – Computing / Learned Society of Wales
Prof Wynne Harlen	Big Ideas of Science Education
Jason Davies	Cardiff MET – Design and Technology
Dr David Barlex	Roehampton University - Design and Technology
Dr Keith Wilson	Cardiff University – Biology
Dr Laura Colucci-Grey	Aberdeen University – science and technology
Brian Berry	Engineering UK / Physics
Peter Trevitt	Royal Society of Chemistry
Andy Mitchell	Curriculum Director, Design and Technology Association
Prof Kevin Flynn	Swansea University – Biology / Learned Society of Wales
Daniele Gibney	Royal Society of Chemists
Gary Williams	Institute of Physics
Dr David Cunnah	Institute of Physics
Prof Tony Campbell	Cardiff University – Biology / Learned Society of Wales
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David Bradley	ERW – Secondary Science Advisor
Barbara George	ERW – Secondary Science Advisor