The Quality of Education:
Computing - Purpose and Provision

St Christopher's:
A Church of England Academy

That person is like a tree planted by streams of water,
which yields its fruit in season
and whose leaf does not wither-
whatever they do prospers.

Psalm 1:3

The Purpose of Study

> "Those who can imagine anything, can create the impossible."
> Alan Turing

Digital literacy is also a key focus, allowing our pupils to use, and express themselves and develop their own ideas through, information and communication technology – at a level suitable for the future workplace and as active participants in a digital world.

Our pupils are nurtured to see, use and evaluate computational abstractions that help them model the state and behaviour of real-world problems and physical systems. Removing the complexity of details and decomposing down to key algorithms that use logical reasoning.

Pupils are introduced to multiple programming languages, styles and paradigms using them to solve a variety of computational problems. Structures used in everyday life are used to understand and devise, design and develop modular programs that use procedures or functions.

The diverse number systems (Binary, Hexadecimal) and Boolean logic are harnessed so that pupils are able to carry out operations in programs and algorithms to satisfy the necessity of efficiency and effectiveness of solutions.

Our pupils, whether progressing to KS4 or higher, understand a wide range of ways to use technology safely, respectfully, responsibly and securely, including protecting their online identity and privacy; recognise inappropriate content, contact and conduct, and know how to report concerns.

Complementing the School Purpose

Foundation Scripture

'Like a tree planted' - Not like one growing wild, and as such our pupils are carefully cultivated, and like the advantages of soil and situ that have been chosen, our pupils are given the academic discipline through our Christian reasoning. Our facilities (hardware & software) and teachers are there to give the pupils the best advantages and opportunities for the modern digital world that has become such an integral part of everyday life.

'By streams of water' - Alluding to the custom of irrigation where streams are directed from a canal or river to different parts of the ground. We hope to give our pupils the building blocks of computing, not necessarily the final build, but the attributes to learn and grow in aspects they have not even thought of yet. Our schemes of learning give the pupils the precise educational curriculum both envisaged by the government and broadened by the knowledge and vision of our department.

'Which yields its fruit in season' - For those who further their studies within the department we offer through our Christian ethos an educational route towards GCSE, which can be achieved with earnest endeavour, with the ripening fruits of their labour rewarded. Within the department our KS4 offerings ensure there is a wide academic range available to fulfil the needs of all our pupils. At KS5, those with the calling to pursue a greater knowledge and understanding are given a deeper, more intellectual observation of the subject.

'Whose leaf does not wither' - As the pressures of the world around our pupils increase with both their academic development and their physical and psychological maturity, we offer consideration and support, so that they flourish rather than 'fall' and seek hope and not despair. The teaching of the subject is such that pupils observe competent modelling of the curriculum to enable understanding, while support for those who need it, is offered freely and consistently.

'Whatever they do prosper' - Overall, it is our aim, that we nourish each and every pupil by providing them with skills to be resilient, encouraging them to build positive social relationships that will take deep root, growing stronger as they find their purpose in life. Just as a tree extending its roots, putting forth, blossoms, leaves and fruit; our pupils will embrace change with confidence and positivity.

Key Themes

Importance *(Knowing what it is to be fully alive)*:

Computer Science is the study of principles and practices that underpin an understanding and modelling of computation, and of their application in the development of computer systems. At its heart lies the notion of computational thinking, a mode that is supported and complemented by a substantial body of theoretical and practical knowledge, and by a set of powerful techniques for analysing, modelling and solving problems. Computational thinking influences many fields such as biology, chemistry, linguistics, psychology, economics and statistics. It empowers pupils to conceptualise and understand computer-based technology, and so are better equipped to function in modern society.

This is fundamentally a practical subject, where invention and resourcefulness are encouraged, but also there is an expectation to apply the academic principles they have learned to the understanding of real-world systems, and to the creation of purposeful artefacts. This combination of principles, practice, and invention makes it an extraordinarily useful and an intensely creative subject, suffused with excitement, both visceral ("it works!") and intellectual ("that is so beautiful").

The 'wider context' *(Learning to live well together)*:

Computer systems have a profound impact on the society we live in, and computational thinking offers a new 'lens' through which to look at ourselves and our world.

- **Intelligence and consciousness.** Pupils are posed questions such as: can a machine be intelligent? ...be conscious? ...be a person? …should they hold the ability to choose life or death?
- **The natural world.** We can model the living world, simulations of animal populations and weather conditions, discuss the outcomes and look for solutions.
- **Creativity and intellectual property.** Games, music, movies, gallery installations and performing arts are all transformed by computing and online experiences. The immersive world once read about in fiction is literally our pupils reality, as teachers we must show guidance and leadership.
- **Moral and ethical implications of using computers.** As our world becomes more interconnected, we should consider privacy and which information should be private and which open to scrutiny; we should question how the vulnerable or the digitally disenfranchised can be protected. Pupils are invited to question the status-quo, develop analytical scrutiny, look for bias and detect opinion, ever searching for 'fact'.

Discipline *(Securing wisdom and understanding)*:

Education enhances pupils' lives as well as their life skills. It prepares young people for a world that doesn't yet exist, involving technologies that have not yet been invented, and that present technical and 'ethical challenges' of which we are not yet aware. To do this, education aspires primarily to teach disciplines with long-term value, rather than skills with short-term usefulness.

A "discipline" is characterised by:

- A body of knowledge, including widely-applicable ideas and concepts, and a theoretical framework into which these ideas and concepts fit.
- A set of techniques and methods that may be applied in the solution of problems, and in the advancement of knowledge.
- A way of thinking and working that provides a perspective on the world that is distinct from other disciplines.
- Longevity: a discipline does not "date" quickly, although the subject advances. Independence from specific technologies, especially those that have a short shelf-life.

These characteristics encompass foundational principles (such as the theory of computation) and widely applicable ideas and concepts (such as the use of relational models to capture structure in data). It incorporates techniques and methods for solving problems and advancing knowledge (such as abstraction and logical reasoning), and a distinct way of thinking and working that sets it apart from other disciplines (computational thinking). It has longevity (most of the ideas and concepts that were current 20 or more years ago are still applicable today), and every core principle can be taught or illustrated without relying on the use of a specific technology.

Christian Virtues

Each pupil in the department should know their own value and self-worth and be appreciated for their uniqueness. We strive to encourage our pupils to grow in confidence, independence and resilience and welcome challenges.

On a daily basis we aim to instil in all pupils St Christopher's core values and virtues. We aim to do this by modelling these values in all our lessons and interactions with pupils and colleagues.

Through our curriculum we aim to challenge the way our pupils think about the digital world in which they live and the impact this has on faith, culture and society. We endeavour to develop pupils who have a broad range of skills, knowledge and wisdom, and the means by which to utilise these beyond the classroom.

As a result we believe that our pupils will be empowered to flourish and prosper.

Curriculum Aims

- Can understand and apply the fundamental principles and concepts of computer science, including abstraction, logic, algorithms and data representation.
- Can analyse problems in computational terms, and have repeated practical experience of writing computer programs in order to solve such problems.
- Can evaluate and apply information technology, including new or unfamiliar technologies, analytically to solve problems.
- Are responsible, competent, confident and creative users of information and communication technology.

Detail Aims of Key Stages 3 and 4

Algorithms: A pupil should understand what an algorithm is, and what algorithms can be used for.

Key Stage 3

- An algorithm is a sequence of precise steps to solve a given problem.
- A single problem may be solved by several different algorithms.
- The choice of an algorithm to solve a problem is driven by what is required of the solution
- The need for accuracy of both algorithm and data

Key Stage 4

- The choice of an algorithm should be influenced by the data structure and data values that need to be manipulated.
- Familiarity with several key algorithms [sorting and searching].
- The design of algorithms includes the ability to easily re-author, validate, test and correct the resulting code.
- Different algorithms may have different performance characteristics for the same task.

Programs: A pupil should know how to write executable programs in at least one language.

Key Stage 3

- Programming is a problem-solving activity, and there are typically many different programs that can solve the same problem.
- Variables and assignment.
- Programs can work with different types of data [integers, characters, strings].
- The use of relational operators and logic to control which program statements are executed, and in what order
    - Simple use of AND, OR and NOT
    - How relational operators are affected by negation *e.g. NOT (a>b) = a≤b+.
- Abstraction by using functions and procedures (definition and call), including:
    - Functions and procedures with parameters.
    - Programs with more than one call of a single procedure.
- Documenting programs to explain how they work.
- Understanding the difference between errors in program syntax and errors in logic.
- Finding and correcting both kinds of errors.

Key Stage 4

- Manipulation of logical expressions, e.g. truth tables and Boolean valued variables.
- One & Two-dimensional arrays
- Programming in a low level language. Procedures that call procedures, to multiple levels. [Building one abstraction on top of another.]
- Programs that read and write persistent data in files.
- Programs are developed to meet a specification, and are corrected if they do not meet the specification.
- Documenting programs helps explain how they work.

Data: A pupil should understand how computers represent data:

Key Stage 3

- Introduction to binary manipulation.
- Representations of:
    - Unsigned integers
    - Text.
    - Sounds
    - Pictures
    - Video

Key Stage 4

- Hexadecimal
- Two's complement
- Signed integers
- String manipulation
- Data compression; lossless and lossy compression algorithms
- Problems of using discrete binary representations
- Representing fractional numbers

Computers: A pupil should know the main components that make up a computer system, and how they fit together (their architecture).

Key Stage 3

- Computers are devices for executing programs
- Computers are general-purpose devices (can be made to do many different things)
- Not every computer is obviously a computer (most electronic devices contain computational devices)
- Basic architecture: CPU, storage (e.g. hard disk, main memory), input/output (e.g. mouse, keyboard)
- Computers are very fast, and getting faster all the time (Moore's law)
- Computers can 'pretend' to do more than one thing at a time, by switching between different things very quickly

Key Stage 4

- Logic gates: AND/OR/NOT.
- Circuits that add. Flip-flops, registers (**).
- Von Neumann architecture: CPU, memory, addressing, the fetch-execute cycle and low-level instruction sets.
- Assembly code. [LittleMan]
- Compilers and interpreters (what they are; not how to build them).
- Operating systems (control which programs run, and provide the filing system) and virtual machines.

Communication and the Internet: A pupil should understand the principles underlying how data is transported on the Internet.

Key Stage 3

- A network is a collection of computers working together
- An end-to-end understanding of what happens when a user requests a web page in a browser, including:
    - Browser and server exchange messages over the network
    - What is in the messages [http request, and HTML]
    - The structure of a web page - HTML, style sheets, hyperlinking to resources
    - What the server does [fetch the file and send it back]
    - What the browser does [interpret the file, fetch others, and display the lot]
- How data is transported on the Internet
    - Packets and packet switching
    - Simple protocols: an agreed language for two computers to talk to each other. [Radio protocols “over”, “out”; ack/nack; ethernet protocol: first use of shared medium, with backoff.]
- How search engines work and how to search effectively. Advanced search queries with Boolean operators.

Key Stage 4

- Client/server model.
- MAC address, IP address, Domain Name service, cookies.
- Routing
- Deadlock and livelock
- Redundancy and error correction
- Encryption and security

Complementing School Provision

Extra-Curricular and Enrichment

- Algorithms Modular arithmetic, Hashing, Distributed algorithms, Optimisation algorithms and heuristics, Graphics [rotating a 3D model]
- Programming: Implementing recursive algorithms, Programming for the real world, Robotics, Object Oriented and Functional languages, App development, Developing for different environments Programming using SDKs and other hardware open source.
- Data: List, Graphs and Trees, Binary tree traversals, Pointers and dynamic data structures, Floating point representation, Computers Interrupts and real-time systems, Multiprocessor systems, Memory caches
- Communications and Internet: Asymmetric encryption, key exchange, Human Computer Interaction (HCI), Recognition of the importance of the user interface, Simple user-interface design guidelines

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