



MINISTRY OF EDUCATION

Computing

for Senior High Schools

TEACHER MANUAL

YEAR THREE



**NATIONAL COUNCIL FOR
CURRICULUM & ASSESSMENT
OF MINISTRY OF EDUCATION**

MINISTRY OF EDUCATION



REPUBLIC OF GHANA

Computing for Senior High Schools

Teacher Manual

Year Three



**NATIONAL COUNCIL FOR
CURRICULUM & ASSESSMENT
OF MINISTRY OF EDUCATION**

COMPUTING TEACHER MANUAL

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INTRODUCTION

The National Council for Curriculum and Assessment (NaCCA) has developed the third and final set of curriculum materials to support the implementation of the new Senior High School curriculum.

This Year Three Teacher Manual for Computing covers all aspects of the content, pedagogy, teaching and learning resources and assessment required to effectively support learners in their final year of Senior High School. All the necessary information for the Student Assessment Portal has been included in the Year Three Teacher Manual to simplify the development of weekly learning plans, meaning that teachers have a single reference document.

The Year Three Teacher Manual has two main objectives:

- To support learners to consolidate and deepen their understanding of the content, pedagogy, and assessment across all three years of the new Senior High School curriculum in preparation for the West Africa Senior Secondary Certificate Examination (WASSCE).
- To equip teachers with the tools and resources needed to deliver revision-focused, assessment-led lessons that build on the knowledge learners have acquired from Year One to Year Three.

In this third year, teachers will be supporting learners to prepare for the WASSCE. Each section of the Teacher Manual is therefore structured around the highest Depth of Knowledge (DoK) levels, allowing learners to build progressively on knowledge acquired from Year One to Year Three. For each week, learning tasks and pedagogy are built around the assessment, ensuring that classroom activities directly prepare learners for the demands of the examination. Two sets of sample examination papers are also provided; one administered by Week 12 as a first semester practice examination, and one by Week 20 as a mock examination, to gauge learners' competencies and identify areas requiring remediation.

To further support teachers in delivering Year Three, NaCCA, working with the Ghana Education Service, has developed a subject specific App for each subject.

The Year Three PLC sessions have been revised in response to findings from the 2025 annual evaluation survey. The survey confirmed that teachers have made strong progress in lesson planning, use of varied instructional methods, ICT integration and modes of assessment. To address the identified gap in explaining concepts clearly using examples familiar to learners, each PLC session now includes a dedicated Content Exploration segment. This ten-minute segment brings the subject group together to work through one challenging problem or concept from the week's Teacher Manual content, not to plan how to teach it, but to ensure that every teacher in the group fully understands it.

The PLC sessions in Year Three also place particular emphasis on connecting the week's content to equivalent topics taught in Years One and Two. Teachers are encouraged to note the recap weeks signposted throughout the Teacher Manual and to use the App to explore how content across all three years links together.

As in previous years, teachers are expected to integrate National Values, Gender Equality and Social Inclusion (GESI), Social and Emotional Learning (SEL), and 21st-century skills into

their learning activities, assessment tasks, and rubrics and mark schemes. The subject-specific App will support teachers in doing this throughout the year.

Ghana Education Service acknowledges the dedication of the teachers who have implemented the new curriculum across Years One and Two and recognises that Year Three represents both the culmination of that effort and a critical moment for learners. The Year Three Teacher Manual and its accompanying resources have been developed to ensure that every learner, regardless of background, ability, or school context, is fully prepared to demonstrate what they know and can do in the WASSCE and to progress confidently to further studies, the world of work, and adult life.

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SECTION 1: BOOLEAN ALGEBRA

STRAND: COMPUTER ARCHITECTURE & ORGANISATION

Sub-Strand: Data Storage and Manipulation

Content Standard: Demonstrate knowledge and understanding of programme Execution and Logic Instructions

Learning Outcome: Apply acquired knowledge and skills of programme execution, logic instructions, and arithmetic operations in the CPU to solve real-life problems.

INTRODUCTION AND SECTION SUMMARY

This section builds on learners' foundational knowledge of computer architecture and network systems, focusing on advanced data manipulation, CPU operations and network design. Learners will explore:

- **Boolean algebra applications** in circuit design and critical points.
- **CPU arithmetic operations** (e.g., shifts, rotations and binary math) and their real-world applications.
- **Network systems**, including topology, scalability, and security practices relevant to Ghanaian contexts (e.g., resource-limited schools or businesses).

The content emphasises on practical problem-solving. For example, learners will analyse how logic gates operations are applied in smart irrigation or how redundancy prevents system design failures. By the end, learners will be equipped to design efficient, secure systems and troubleshoot hardware/software issues—skills vital for further studies or careers in tech.

Focal Areas Covered:

Week 1

1. Understanding Critical Points
2. Understanding Fail-Safes and Redundancy
3. Optimisation and Problem-Solving through Logic Synthesis

Week 2: Shift/Rotation Operations & Boolean Algebra Connection

Week 3

1. Comparing Repeated Addition vs. Shift-and-Add Multiplication
2. Binary subtraction using two's complement (4-bit Binary)
3. Python application of arithmetic operations to real-world problems

SUMMARY OF PEDAGOGICAL EXEMPLARS

In this section, learners investigate core system reliability by identifying critical failure points and engineering fail-safes and redundancy into digital architectures. Hands-on design exercises focus on optimization and problem-solving through logic synthesis, bridging the gap between Boolean algebra and bit-level shift and rotation operations. Moving into low-level computer arithmetic, learners compare the efficiency of repeated addition against shift-and-add multiplication algorithms and practice 4-bit binary subtraction using two's complement. Finally, these hardware-level concepts are reinforced through practical Python programming, where learners apply fundamental arithmetic operations to model and solve real-world engineering problems.

ASSESSMENT SUMMARY

Depth of Knowledge (DOK) is employed in the assessment of learners to enhance the quality, validity and fairness of assessments while promoting deeper learning and critical thinking skills. Various forms of assessments are conducted to determine the learners' performance on the concepts that will be taught under this section. Teachers are entreated to administer these assessments and the record as hinted above for onward submission into the Student Assessment Portal (SAP).

Week	Indicator	DoK Level	Assessment Mode
1	Determine and apply critical points of Logic Operations to solve a problem	4	Homework
2	Describe the arithmetic operations in the CPU, specifically Rotation and Shift Operations, and explain their real-life applications.	2	Essay
3	Discuss 3 major Arithmetic Operations and apply them taking into consideration their various functions.	2	Discussion

WEEK 1

Learning Indicator: Determine and apply critical points of Logic Operations to solve a problem

Recap Weeks

Year 1	Week 1–3: Describe information as bit patterns.
Year 2	Week 1: Determine critical points of logic operations and apply them to solve problems efficiently. Week 2: Apply the concepts of Boolean expressions to simplify circuits.

FOCAL AREA 1: UNDERSTANDING CRITICAL POINTS

Critical Points are *vital inputs, outputs, or internal paths* where a fault (e.g., wrong logic level, signal dropout) can lead to total system failure or undesirable behaviour. Imagine it like the automatic lights that come on when it gets dark. This automatic lighting system is made of many interconnected parts, and the critical points are those specific inputs, outputs, or internal pathways that can have a major impact when there is a single fault. This kind of faults could be a signal getting stuck at the wrong level (e.g., a ‘0’ when it should be a ‘1’), a signal dropping out completely, or a connection breaking.

Examples

1. The smart thermostat is an input sensor of a smart device. If this sensor fails and incorrectly reports the room is cold, the heating might run constantly, wasting energy. If it fails and indicates the room is hot, the heating might never come on.
2. In a digital clocks or calculator, a broken logic path that carries a signal for displaying a particular number segment will display incorrect signals. Let’s say the critical point for displaying the top bar of a “7” is broken, then all numbers needing that bar will display incorrectly like displaying “7” as “/”.
3. Imagine at the traffic lights, the input that signals cars to wait at a red light fails due to heavy rains, the light might stay red indefinitely or the traffic light may not work at all, causing a major traffic jam.

Let’s consider a real-life scenario and break it down to identify the logics.

There is a system designed to automatically water crops on a farm in Ziavi, Ho, where water conservation is important. The identified critical points in the logic are as follows:

1. A Moisture Sensor is placed in the soil. It is designed to send out a digital signal: ‘1’ (representing HIGH or TRUE) if the soil is too dry and needs water.
2. A Timer is also part of the system. It sends out a ‘1’ if it’s within the scheduled watering times (e.g., early morning or late evening to reduce evaporation).
3. The water Pump should only activate if both the soil is dry AND it is the correct watering time. This “both conditions must be true” scenario immediately tells us we need AND logic.

The mapped logic circuit is shown in Figure 1.1.

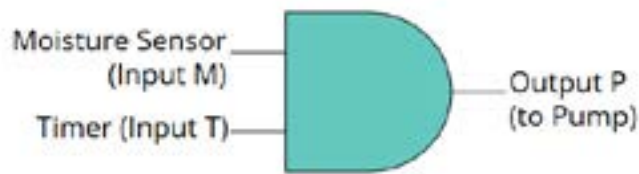


Figure 1.1 Water System Logic Circuit

The AND gate works as a safety lock: the pump turns on only when both the moisture sensor and the timer are on, preventing accidental watering if only one is ready.

FOCAL AREA 2: UNDERSTANDING FAIL-SAFES AND REDUNDANCY

When analysing critical points in logic systems, we are looking for weaknesses. “Fail-safe” designs and “redundancy” are two key engineering strategies to make systems more resilient to faults.

1. Fail-Safe Flip-Flops:

First, what’s a flip-flop? It is a fundamental building block in digital sequential logic circuits. Think of it as a basic memory cell that can store one bit of information (either a ‘0’ or a ‘1’). They are essential in control systems, counters (like in a digital clock), and registers (for temporary data storage in a CPU).

Fail-safe flip-flops are specially designed versions that are smarter about handling errors:

- They are designed to default to a known ‘safe’ state if the main power supply fails or if an invalid or unexpected signal is detected. For example, in a railway signalling system, a ‘safe’ state might be to turn all signals to ‘red’ (stop).
- They can often detect internal errors, such as glitches in the clock signal that controls them or if their output gets stuck at a certain value (stuck-at faults).
- Their main purpose is to provide system continuity or a safe shutdown by preventing the system from entering a dangerous or unpredictable state when a fault occurs.

2. Redundancy – Having a Backup Plan

Redundancy, in simple terms, means having extra components or backup systems that can take over if the primary component or system fails. It is like having a spare tyre in your car – if one tyre gets a puncture, you have a backup to keep you going.

It is a core strategy in designing highly reliable systems, especially in situations where a failure could cause significant harm, financial loss, or major disruption (like aircraft control systems, hospital life support, or banking systems).

Types of Redundancy

1. Hardware Redundancy: This involves having duplicate physical components.

Example: Using two moisture sensors in the smart farm instead of one. If one sensor fails, the other can still provide a reading.

2. **Logic Redundancy:** This means designing the circuit with additional logic paths to achieve the same result, or to handle failures.

Example: In the security system, instead of just one AND gate, you might have a more complex arrangement perhaps involving OR gates with backup inputs, so if one path fails, another can still trigger the alarm under the right conditions.

3. **Time Redundancy:** This involves repeating an operation or re-checking signals at different time intervals to confirm accuracy.

Example: A system might read a sensor value three times and take the majority reading, on the assumption that a single erroneous reading due to noise is less likely to occur three times in a row.

From Figure 1, we can add redundant sensors to improve the system. As shown in figure.

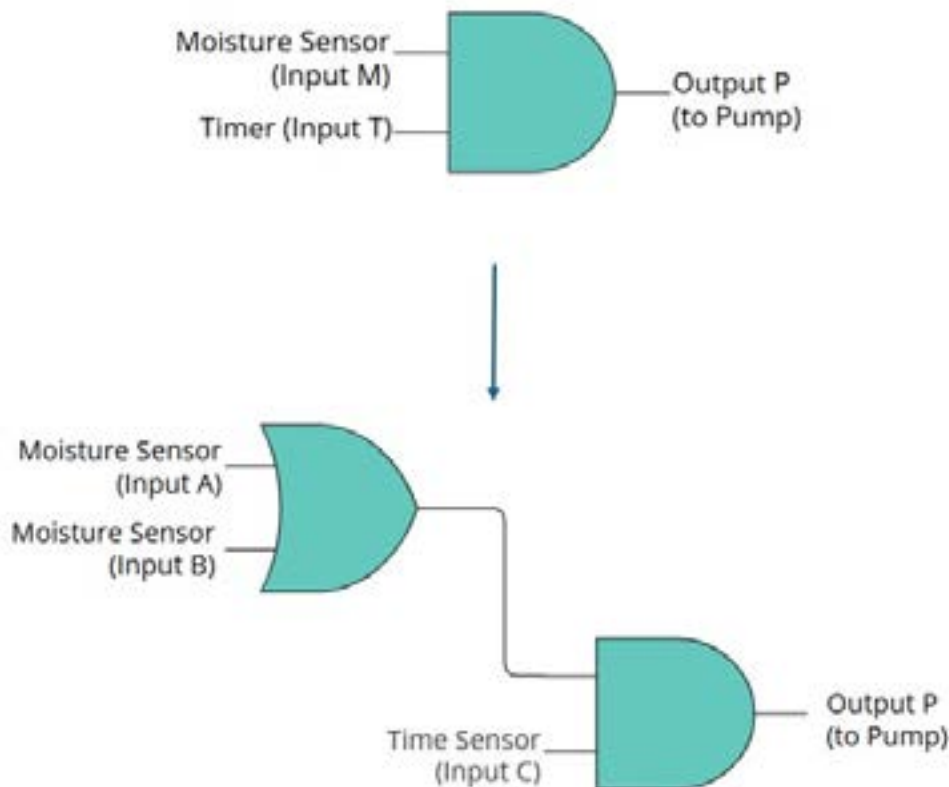


Figure 1.2 Improved Water System with Redundancy

From the improved system we have two moisture sensors, Sensor A and Sensor B. Both are checking the soil moisture. Their outputs go to an OR gate. The OR gate will output a '1' if Sensor A is '1' OR Sensor B is '1' (or if both are '1').

This means if either sensor (or both) correctly detects that the soil is dry (sends a '1'), the OR gate will send a '1' to the AND gate. The AND gate then only needs the Timer to also be '1' to activate the Water Pump.

FOCAL AREA 3: OPTIMISATION AND PROBLEM-SOLVING THROUGH LOGIC SYNTHESIS

Optimisation

Logic synthesis can be used to optimise circuits to ensure better performance and reliability. In the context of logic design, optimisation refers to the process of modifying a circuit design to improve its characteristics without changing its fundamental behaviour or function. The goals are typically:

- 1. Reducing the number of logic gates (which can reduce cost and physical size).
- 2. Minimising propagation delay (the time it takes for a signal to travel through the gates, meaning a faster circuit).
- 3. Saving power consumption (fewer gates or more efficient types of gates can use less energy)

Optimisation Techniques

Technique	Description	Example
Gate Reduction	Using fewer gates to achieve the exact same logical output. This often involves applying Boolean algebra rules.	Reducing an AND gate followed by a NOT gate into a single NAND gate (since $A \cdot B$ is NAND).
Gate Type Simplification	Use universal gates like NAND/NOR only	All logic functions can be built using only NAND
Timing Optimisation	Minimise delay by reducing gate levels	Choose fastest logic path

Example

Expression:

$$Y = A \cdot B + A \cdot \bar{B}$$

Simplify:

$$Y = A$$

This eliminates the need for an AND, NOT and OR gate—saves time and space.

Learning Tasks

- Imagine a home security system is designed to trigger an alarm if, and only if, two different motion sensors (Sensor A and Sensor B) both detect movement simultaneously. The mapping for this circuit is illustrated in figure 1.3. Identify the flaw of this circuit.

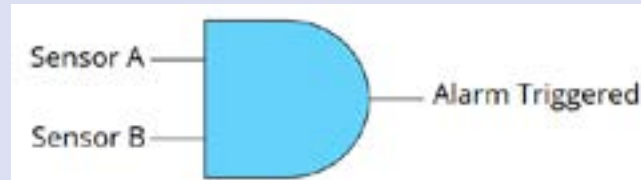


Figure 1.3 Alarm System

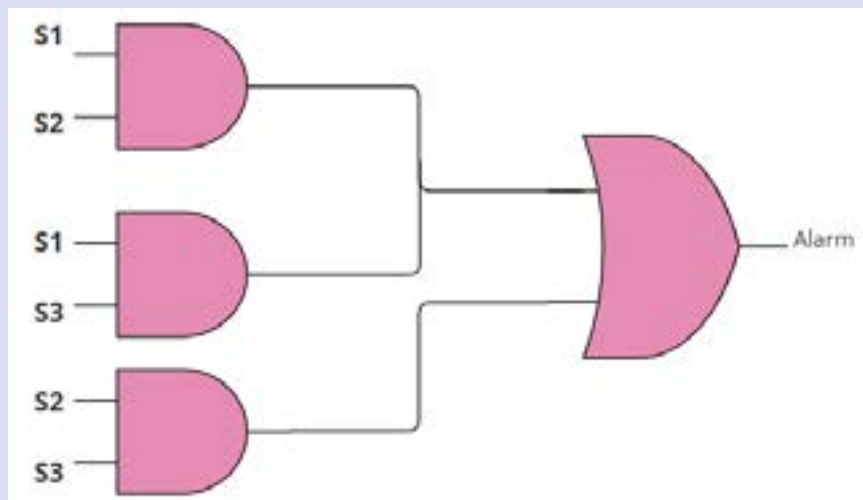
- Learners read and discuss the improvement of the system based on this text: Imagine we add a flip-flop that remembers if the alarm has been triggered. So, once triggered, it stays ON until reset. If there is a brief power dip or some electrical noise, a standard flip-flop might get reset randomly, perhaps turning the alarm OFF. A fail-safe flip-flop in this situation would be designed to reset to a state that keeps the system secure – for example, it might ensure the alarm stays ON, or that a door lock controlled by the system remains engaged.
- Learners improve the alarm system by drawing a new logic for the system and explain their rationale for the changes.
- List some examples of real-world systems that are not perfect. How might sensor failures or broken components affect their performance?
 - Why is it important to design systems that remain strong and reliable even when faults occur? Can you think of ways engineers address these challenges?
- Design a 3-Input Voting System (Scaffolded) based on this scenario.
3 sensors (S1, S2, S3) vote to activate an alarm system.
If at least 2 out of 3 sensors are active, the output turns ON.
- First design a truth table for the alarm system.

S1	S2	S3	Output
0	0	0	0
0	0	1	0
0	1	0	0
0	1	1	1
1	0	0	0
1	0	1	1
1	1	0	1
1	1	1	1

- Write a logic expression for the system

$$Y = S_1S_2 + S_1S_3 + S_2S_3$$

- c. Draw a gate diagram for the system



Pedagogical Exemplars

1. The teacher facilitates an open conversation with learners on identifying the flaws in the system and how flip-flops help improve the system.
2. Teacher guides learners to draw a new logic for the system
3. Teacher facilitates a question-and-answer section on sensor failures and importance of designing reliable systems
4. Teacher guides learners to optimise the alarm system.

Key Assessment: Homework

Recap assessment

DoK Level 2

1. Draw a logic gate diagram using **AND gates only** to represent the correct circuit operation. In a moisture-controlled irrigation system, the moisture sensor (M) is expected to send **1** when the soil is dry, and the timer (T) sends **1** during watering time.
2. Explain how **hardware redundancy** can help fix a problem where the moisture sensor fails in the smart irrigation system.

DOK Level 3

3. A student proposes a modified smart farm system using two sensors, A and B, connected to an OR gate, which feeds into an AND gate with a timer input T. Construct a truth table with inputs A, B, and T and output P (Pump), where: Pump should turn ON if **either A or B detects dryness AND** it's the right time ($T = 1$).

A	B	T	P
0	0	0	
0	0	1	

A	B	T	P
0	1		
0	1	1	
1	0	0	
1	0	1	
1	1	0	
1	1	1	

4. Propose one **logic redesign** to prevent total failure of the alarm system if one motion sensor is stuck at 0 in the security system circuit using AND logic.

DOK level 4

5. Name three critical points in any circuit and explain why they are critical. If any fails, what would happen? Suggest a way to fix or prevent such a failure in the circuit.

6. Scenario Question

A smart farm uses a circuit that activates the water pump only when both the moisture sensor and a timer signal are HIGH (1). You observe that sometimes, although the soil is dry, the pump does not activate.

- Identify two critical points in this system and explain why they are critical.
- Propose a logic circuit redesign using redundancy to handle sensor failure. Your redesign should involve at most 4 inputs.
- Draw the revised logic diagram and describe its function.

(10 marks)

7. Design a 3-input voting system for a critical fire detection system. The sensors are S1, S2, and S3. The alarm must activate if at least two of the three sensors detect smoke.
- Construct the truth table for this system.
 - Write the Boolean expression for the alarm output.
 - Propose a method to make this fire alarm design fault tolerant. This means the system should ideally still work correctly (or at least fail safely) even if one of its logic gates fails.
 - Justify your answer, explaining how your proposal improves fault tolerance.

(20 marks)

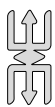
PLC Session 1

45 minutes

Planning & Reviewing the Learning Plan

1. Begin the session by recapping lessons from the previous year/session/week, focusing on how learning was applied.

2. Use your subject specific app to explore the content before planning. Ask the app to
 - a. explain the week's concepts in a practical way that will make it easier for learners to understand
 - b. identify two or three common misconceptions learners may have on the week's content and how to address them using contexts familiar to Ghanaian learners. (NTS 3a, 3g and 3m).
3. Use your subject specific app to plan your lesson. Ask the app to
 - a. suggest the most effective method for teaching the week's concepts to learners with diverse backgrounds.
 - b. suggest learning activities, differentiation and essential questions based on the method of teaching (NTS 3a-3q)
 - c. review your prepared learning plan and address any challenging issues you may have identified in your subject area (NTS 3a-3c).



Note

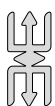
- Take note of the recap topics linked to Years 1 and 2 while preparing for your lesson.
- Refer to the Values Learning Community Handbook and link the values for the week in your lesson to ensure that learners are applying what they learn.

4. Plan the week's key assessment with your app
 - a. The key assessment for the week is **homework**. Chat with your app to plan this assessment, indicating what you and your learners will do before, during and after the homework (NTS 3k-3q).

10 minutes

Content Exploration

5. As a subject group, select one problem or idea/term in the week's content that is challenging (not a routine procedural question, but one that requires conceptual understanding) and then
 - a. use the app, ask it to solve the problem step by step and explain the reasoning behind each step (you may be assisted by a teacher who is strong in the content area)
 - b. all teachers in the group work through a similar problem individually for 3–4 minutes
 - c. the group then works through the problem together step by step
 - d. highlight the most common errors made at each step and discuss (NTS 1c, 1e, 2c, 2e, 3e-3j).



Note

- This part is not just about 'How do I teach this?' but how do I teach it for learners to understand?
- If the group still shares the same content gap, use the app: ask it to solve the problem step by step and explain the reasoning behind each step.

- Problems/ideas discussed should be sourced from the Teacher Manual content, not invented separately. This keeps the content exploration directly connected to what teachers will deliver.

30 minutes

Enactment

6. Enact a teaching activity based on your learning plan (NTS 1a-1b, 1e-1g, 2c, 2e, 2f, 3c-3j and 3o).
 - a. Colleagues observe with specific attention to clarity of concept explanation, use of familiar Ghanaian examples and how misconceptions are handled if they arise.
 - b. After the enactment, ask for structured feedback from the group
 - i. was the concept explained in a way that a learner with no prior knowledge could follow?
 - ii. were the examples grounded in contexts familiar to Ghanaian learners?
 - iii. did any misconceptions surface and if so, how were they addressed?

5 minutes

Reflection

7. Reflect and share your views on the session. One thing that worked well, what did not work well and what you will do differently. (NTS 1a, 1b).
8. Identify a critical friend to observe and provide feedback on your lesson in relation to the PLC Session conducted (NTS 1f, 1g).
9. Remember to
 - a. transfer your chats into your learning planner template.
 - b. read your Teacher Manual and related Learner Material in preparation for the next session. Take note of the recap weeks, which are linked to Years 1 and 2 (NTS 3a).
 - c. integrate National Values, GESI, SEL, and 21st century skills into your learning activities, assessment tasks, and rubrics/mark schemes.

WEEK 2

Learning Indicator: Describe the arithmetic operations in the CPU, specifically Rotation and Shift Operations and explain their real-life applications

Recap Weeks

Year 1	Week 3: Describe the functions of the parts of the CPU: Arithmetic and Logic Unit (ALU), Control Unit (CU) and registers.
Year 2	Week 3: Discuss 3 major arithmetic operations and apply them, considering their various functions

FOCAL AREA: SHIFT/ROTATION OPERATIONS & BOOLEAN ALGEBRA CONNECTION

Quick recap: Computers think in binary – patterns of 0s and 1s. For example, the decimal number 13 is 00001101 in 8-bit binary.

Shift and rotation operations are actions that move these bits to the left or right within their binary representation. These Operations are useful because

1. **Super-Fast Multiplication & Division:** Shifting bits is often much faster for a CPU than performing traditional multiplication or division, especially when dealing with powers of 2. Think of how you can multiply a decimal number by 10 by just adding a zero at the end – shifting bits is similar for binary and powers of 2.
2. **Data Compression:** They can help pack multiple pieces of information into a single binary number, saving space. Imagine efficiently storing two small numbers in the space usually taken by one larger one.
3. **Cryptography & Low-Level Programming:** These operations are fundamental building blocks in algorithms for encrypting data (making it secret) and in system-level programming where you need direct control over data bits.

Types of Shift Operations

1. **Logical Shift:** This is the most straightforward type of shift.

Bits in the binary number are simply moved to the left or right by a specified number of positions. When bits are shifted, empty spaces are created. In a logical shift, these empty spaces are always filled with 0s.

Note: Logical shifts do not preserve the sign bit (the leftmost bit, which in signed number representation indicates if a number is positive or negative). This means they are primarily used for unsigned numbers (numbers that are always considered positive).

Example (using a 8-bit binary number 00001101, which is 13 in decimal):

Original: 0 0 0 0 1 1 0 1

- a. **Logical Left Shift by 1 position:** The bits move one place to the left. The leftmost '1' "falls off" and is lost. A '0' is brought in to fill the empty space on the right. 00001101

$\rightarrow$ 00011010 (The new number is 26 in decimal, demonstrating $13 \times 2 = 26$).

- b. **Logical Right Shift by 1 position:** The bits move one place to the right. The rightmost '1' "falls off" and is lost. A '0' is brought in to fill the empty space on the left. 00001101 $\rightarrow$ 00000110 (The new number is 6 in decimal, demonstrating integer division $13 \div 2 = 6$).

Real-Life Analogy (Logical Shift): Imagine a line of learners sitting in chairs. If you ask them to "shift left by one seat," the student on the far left has nowhere to go (they're "lost"), and an empty seat appears on the far right, which a new student (a '0') fills.

2. **Arithmetic Shift:** This type of shift is designed to work correctly with signed numbers (positive and negative integers). It is similar to a logical shift, but its key feature is that it preserves the sign bit (the leftmost bit). This is vital to ensure that a negative number stays negative after a shift, and a positive number stays positive (mostly for right shifts).
 - a. **Arithmetic Right Shift:** When bits are shifted right, the empty spaces created on the left are filled with a copy of the original sign bit. So, if the number was positive (sign bit '0'), '0's are shifted in. If it was negative (sign bit '1'), '1's are shifted in.
 - b. **Arithmetic Left Shift:** This typically fills the new empty bits on the right with '0's (similar to a logical left shift). However, a major caution: an arithmetic left shift can cause an overflow if the value changes so much that the sign bit itself is altered, effectively changing a positive number to negative or vice-versa unexpectedly. The CPU usually has ways to detect this (overflow flags).

Example (using a 4-bit signed binary number 1011):

If we interpret 1011 using two's complement (a common way to represent signed numbers), where the leftmost bit is the sign bit: '1' means negative. 1011 represents -5 in decimal.

Original: 1 0 1 1 (Sign bit is '1', so it is negative)

- i. **Arithmetic Right Shift by 1 position:** The rightmost '1' falls off. The sign bit ('1') is copied into the new leftmost empty space. 1011 $\rightarrow$ 1101 (This is -3 in decimal. The number remained negative). Note: While shifting right by 1 position divides positive numbers by 2, for signed odd integers like -5, $-5 \div 2 = -2.5$. In computer arithmetic, an arithmetic right shift performs floor division, rounding down toward negative infinity. Therefore, -2.5 rounds down to -3.
- ii. **Arithmetic Left Shift by 1 position:** A '0' is brought in on the right. The leftmost bit (original sign bit) might change. 1011 (-5) $\rightarrow$ 0110 (+6). Notice the sign has flipped from negative to positive! This is an example of overflow where the result 0110 (+6) doesn't make sense as "(-5) shifted left by 1". This happens because the operation effectively tried to make a number too large (in magnitude) for the available bits while keeping the sign, and the sign bit itself was overwritten.

Real-Life Application: Imagine the line of learners again, but this time the student on the far left is the "leader" (the sign bit). If the line shifts right, the leader makes sure that any new student joining at the front is "like them" (same sign).

3. **Circular Shift (also known as Rotation):** In this type of shift, no bits are lost. Bits that "fall off" one end of the number simply wrap around to the other end.

Example (using a 4-bit binary number 1101):

Original: 1 1 0 1

- iii. **Circular Left Shift by 1 position (Rotate Left):** The leftmost ‘1’ falls off but wraps around to become the new rightmost bit. $1101 \rightarrow 1011$
- iv. **Circular Right Shift by 1 position (Rotate Right):** The rightmost ‘1’ falls off but wraps around to become the new leftmost bit. $1101 \rightarrow 1110$

Use Case: Circular shifts are very useful in cryptography (for scrambling data in a reversible way) and in some error detection and correction algorithms.

Real-Life Application: Think of learners sitting in a circle. If everyone shifts one seat to the left, the student who was on the “end” of the line (if it were straight) simply moves to the “beginning” seat on the other side. No one leaves the circle.

Real-Life Application

1. Caesar Cipher (Encryption):

In a simple Caesar cipher, letters are shifted by a certain number of positions (e.g., A becomes D with a shift of +3).

A binary version uses circular shifts to scramble data. For example, rotating 1101 left gives 1011. This is a simple form of encryption sometimes used in embedded systems.

2. Fast Maths in CPUs:

- a. Left shift ($\ll$) is like multiplying by 2 for each position shifted.
 - i. e.g., 0010 (2) $\ll 1 \rightarrow 0100$ (4).
 - ii. e.g., 00011010 (26) $\ll 1 \rightarrow 00110100$ (52).
- b. Right shift ($\gg$) is like dividing by 2 for each position shifted (for arithmetic shifts on signed numbers, or logical shifts on unsigned numbers).
 - i. e.g., 1100 (-4, signed) $\gg 1 \rightarrow 1110$ (-2, arithmetic shift).
 - ii. e.g., 00011010 (26, unsigned) $\gg 1 \rightarrow 00001101$ (13, logical or arithmetic if positive)

Learning Tasks

1. Learners watch a demonstration of how shifts are used to enhance understanding.
2. Convert decimal numbers (e.g., 13, -6) to 8-bit binary.

Solving Process

- a. Repeatedly divide by 2 and note the remainders:
 - $13 \div 2 = 6$ remainder 1 (This is your Least Significant Bit - LSB)
 - $6 \div 2 = 3$ remainder 0
 - $3 \div 2 = 1$ remainder 1
 - $1 \div 2 = 0$ remainder 1 (This is your Most Significant Bit - MSB)
- b. Read the remainders in reverse order (from MSB to LSB): 1101.

- c. Pad with leading zeros to make it 8 bits: 00001101. So, 13 in 8-bit binary is 00001101.

3. Converting Negative Numbers (e.g., -6) – Using Two's Complement

Solving Process

- a. Get the absolute value: The absolute value of -6 is 6.
- b. Convert the absolute value to binary (8-bit in this case):
 - $6 \div 2 = 3$ remainder 0
 - $3 \div 2 = 1$ remainder 1
 - $1 \div 2 = 0$ remainder 1

- c. So, 6 in binary is 110. Padded to 8 bits: 00000110

4. Perform logical left shift 1101 by 2 positions

- a. If it is a 4-bit number:

Original 1101.

- i. Shift 1: 1010.
- ii. Shift 2: 0100.

Result: 0100.

- b. If it is unbounded (or padded, e.g., 001101):

- i. Shift 1: 011010.
- ii. Shift 2: 110100.

Result: 110100

4. Learners in their groups solve this problem: Combine 1101 (13) and 0110 (6) to make one 8-bit byte using shifts.

Steps

- a. Take the first number (1101) and shift it left by 4 bits. This makes it 11010000. (The original 4 bits are now in the upper half of the 8-bit byte, and the lower half is filled with zeros).
 - b. Use the bitwise OR operation to merge this with the second number (0110, which can be written as 00000110 in 8 bits). $11010000 \text{ OR } 00000110 = 11010110$
 - c. How does this apply to file formats, for example, storing RGB colour values where red, green and blue components (each often 8 bits) are packed together?
5. Learners in their groups solve this scenario question: A weather sensor records two 4-bit temperatures, for example, 1011 (11°C) and 0100 (4°C). Pack them into one 8-bit byte.

Step-by-Step Solution:

- a. First temperature: 1011 (11°C)
- b. Second temperature: 0100 (4°C)

We want to pack them into an 8-bit byte like this: 10110100, so let's break it in steps.

- c. Step 1: Shift the first temperature (1011) left by 4 bits.

This is because we want it to occupy the left side (the higher 4 bits) of the 8-bit byte.

1011 shifted left by 4 becomes 10110000. Four zeros are added on the right.

- d. Step 2: Use the bitwise OR operation to add the second temperature (0100) into the lower 4 bits of the byte.

10110000 OR 00000100 (which is 0100 padded to 8 bits for the OR operation)

Equals 10110100.

- e. Final Answer: The packed byte is 10110100 (binary), which is 180 in decimal holds both temperatures

How to Remember This: Think of the 8-bit byte as a minibus ('trotro') with 8 seats. The first temperature is a group of 4 people who sit in the front 4 seats (you 'shift' them forward/left). Then the second temperature group comes and fills the back 4 seats

6. Present your solutions

Pedagogical Exemplars

1. Teacher demonstrates by solving problem of how shifts are used
2. Teacher guides learners to solve task questions.

Key Assessment: Group Project

DOK Level 2

1. State one key difference between logical and arithmetic shifts with an example (2 marks).
2. Shift the number 26 right arithmetically by 1 bit and interpret the result. (4 marks)
3. Match each scenario to the correct shift operation (4 marks, 1 mark each)

Scenario	Shift Type
1. Doubling a number	Logical Left Shift (or Arithmetic Left Shift)
2. Preserving negative signs	Arithmetic Right Shift
3. Creating a password cipher	Circular Shift
4. Dividing unsigned data	Logical Right Shift

Hint



Assign Group Project to learners and give them reasonable time to complete it. Use the SS App to generate the project as well as the rubric. Learners' projects should be marked immediately and scores entered into the SAP.

Sample Group Project Work

Nature of Task: Research work

Duration: 5 Weeks

Required Resources: laptops or desktop computers with internet access

Task

1. Research on how to install your assigned operating system on a computer
2. Prepare an installation guide document to share with the class.

Rubric

Criteria	Excellent (5 marks)	Very Good (4 marks)	Good (3 marks)	Satisfactory (2 marks)	Needs Improvement (1 mark)
System Requirements	Lists 5+ specific hardware and software requirements (processor, RAM, storage space, BIOS settings, pre-installation tasks)	Lists 4 specific hardware and software requirements	Lists 3 specific hardware and software requirements	Lists 2 specific hardware and software requirements	List 1 specific hardware and software requirement
Step-by-Step Instructions	Provides 60%+ numbered steps from beginning to end instructions for each action on preparation, installation process, and post-installation setup.	Provides 50%+ numbered steps from beginning to end instructions for each action on preparation, installation process, and post-installation setup.	Provides 30%+ numbered steps from beginning to end instructions for each action on preparation, installation process, and post-installation setup.	Provides 20%+ numbered steps from beginning to end instructions for each action on preparation, installation process, and post-installation setup.	Provides 10%+ numbered steps from beginning to end instructions for each action on preparation, installation process, and post-installation setup.
Visual Documentation	Includes 5+ relevant screenshots or images for each major step as illustrations	Includes 4 relevant screenshots or images for each major step as illustrations	Includes 3 relevant screenshots or images for each major step as illustrations	Includes 2 relevant screenshots or images for each major step as illustrations	Includes 1 relevant screenshot or image as an illustration.

Class Presentation	90% of groups' members are involved in the presentation and have understanding of the document	80% of groups members are involved in the presentation and have understanding of the document	70% of groups members are involved in the presentation and have understanding of the document	60% of groups members are involved in the presentation and have understanding of the document	50% of groups members are involved in the presentation and have understanding of the document
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How to Administer

1. Organise the learners into small groups.
2. Let members of each group choose their operating system (Microsoft Windows, macOS, Ubuntu, Fedora and Chrome OS)
3. Inform them about the duration of the project
4. Share the rubric evaluation criteria before they start the project
5. Use rubric for evaluation

How to provide Feedback

1. Highlight specific strengths as groups present their work
2. Highlight areas of improvements
3. Guide learners to make corrections in their installation guide steps if there are missing steps or inconsistencies.

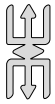
Note: Refer to the TAMT pages 27-29 or use PlayLab to generate more information on how to administer and provide feedback.

PLC Session 2

45 minutes	Planning & Reviewing the Learning Plan
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1. Begin the session by recapping lessons from the previous session, focusing on how learning was applied.
2. Use your subject specific app to explore the content before planning. Ask the app to
 - a. explain the week's concepts in a practical way that will make it easier for learners to understand.
 - b. identify three common misconceptions learners may have on the week's content and how to address them using contexts familiar to Ghanaian learners (NTS 3a, 3g and 3m).
3. Use your subject specific app to plan your lesson. Ask the app to
 - a. suggest the most effective method for teaching the week's concepts to learners with diverse backgrounds.
 - b. suggest learning activities, differentiation and essential questions based on the method of teaching (NTS 3a-3q).

- c. review your prepared learning plan and address any challenging issues you may have identified in your subject area (NTS 3a-3c).



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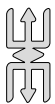
- Take note of the recap topics linked to Years 1 and 2 while preparing for your lesson.
- Refer to the Values Learning Community Handbook and link the values for the week in your lesson to ensure that learners are applying what they learn.

4. Use your app to plan and administer the mode of assessment for the Student Assessment Portal (SAP).
- a. The key assessment for the week is **group project**. Chat with your app to plan this assessment by reviewing or developing the assessment items/tasks and marking schemes/rubrics for the project (NTS 3k-3q).

10 minutes

Content Exploration

5. As a subject group, select one problem or topic/idea/term in the week's content that is challenging (not a routine procedural question, but one that requires conceptual understanding) and then
- use the app, ask it to solve the problem step by step and explain the reasoning behind each step (you may be assisted by a teacher who is strong in the content area)
 - all teachers in the group work through the problem individually for 3–4 minutes
 - the group then works through it together the problem, step by step
 - highlight the most common errors made at each step (NTS 1c, 1e, 2c, 2e, 3e-3j).



Note

- This part is not 'How do I teach this?' but how do I teach it for learners to understand?
- If the group still shares the same content gap, use the app: ask it to solve the problem step by step and explain the reasoning behind each step.
- Problems/ideas discussed should be sourced from the Teacher Manual content, not invented separately. This keeps the content exploration directly connected to what teachers will deliver.

30 minutes

Enactment

6. Enact a teaching activity based on your learning plan (NTS 1a-1b, 1e-1g, 2c, 2e, 2f, 3c-3j and 3o).
- Colleagues observe with specific attention to clarity of concept explanation, use of familiar Ghanaian examples and how misconceptions are handled if they arise.
 - After the enactment, ask for structured feedback from the group
 - was the concept explained in a way that a learner with no prior knowledge could follow?
 - were the examples grounded in contexts familiar to Ghanaian learners?

iii. did any misconceptions surface and if so, how were they addressed?

5 minutes	Reflection
7. Reflect and share your views on the session. One thing that worked well, what did not work well and what you will do differently. (NTS 1a, 1b). 8. Identify a critical friend to observe and provide feedback on your lesson in relation to the PLC Session conducted (NTS 1f, 1g). 9. Remember to a. transfer your chats into your learning planner template. b. read your Teacher Manual and related Learner Material in preparation for the next session. Take note of the recap weeks, which are linked to Years 1 and 2 (NTS 3a). c. integrate National Values, GESI, SEL, and 21st century skills into your learning activities, assessment tasks, and rubrics/mark schemes.	

WEEK 3

Learning Indicator: Discuss 3 major Arithmetic Operations and apply them taking into consideration their various functions

Recap Weeks

Year 1	Week 3: Describe the functions of the parts of the CPU: Arithmetic and Logic Unit (ALU), Control Unit (CU) and registers.
Year 2	Week 3: Discuss 3 major arithmetic operations and apply them, considering their various functions

FOCAL AREA 1: COMPARING REPEATED ADDITION VS. SHIFT-AND-ADD MULTIPLICATION

1. Repeated Addition:

Example:

$$5 \times 3 = 5 + 5 + 5 = 15.$$

Disadvantage: This is slow for large numbers.

For instance, 1000×1000 would need 1000 addition operations.

2. Shift-and-Add (Bitwise Optimisation):

This method is based on how binary multiplication works.

Example:

5×3 in 4-bit binary:

Multiplicand: $5 = 0101_2$

Multiplier: $3 = 0011_2$

$$\begin{array}{r}
 0101 \quad (5) \\
 \times 0011 \quad (3) \\
 \hline
 0101 \quad (0101 \times 1 - 1st \text{ bit of } 3) \\
 01010 \quad (0101 \times 1 - 2nd \text{ bit of } 3, \text{ shifted left by } 1) \\
 000000 \quad (0101 \times 0 - 3rd \text{ bit of } 3, \text{ shifted left by } 2) \\
 +0000000 \quad (0101 \times 0 - 4th \text{ bit of } 3, \text{ shifted left by } 3) \\
 \hline
 00001111 \quad (15 \text{ in decimal})
 \end{array}$$

This process involves checking the bits of the multiplier (3). If a bit is 1, you add the multiplicand (5), shifted appropriately. If the bit is 0, you add nothing (or zero).

FOCAL AREA 2: BINARY SUBTRACTION USING TWO'S COMPLEMENT (4-BIT BINARY)

This is how computers perform subtraction by using addition.

To calculate $A - B$, Lets compute $7 - 5$ in binary.

Step 1: Represent 7 and 5 in 4-bit binary.

$$7 = 0111$$

$$5 = 0101$$

Step 2: Find the two's complement of 5 (which represents -5).

Original 5: 0101

Invert all bits (1's complement): $0101 \rightarrow 1010$.

Add 1: $1010 + 1 = 1011$.

So, 1011 is the 4-bit two's complement representation of -5.

Step 3: Add $7 + (-5)$ using their binary forms:

0111 (7)

+ 1011 (-5)

10010

Since we are working with 4-bit numbers, we discard any overflow bit that goes beyond the 4th position (the '1' at the far left).

So, the result becomes 0010 (which is 2 in decimal).

FOCAL AREA 3: PYTHON APPLICATION OF ARITHMETIC OPERATIONS TO REAL-WORLD PROBLEMS

Let's look at how python can be applied in these two areas: temperature conversion and floating-point precision issues. We will write codes for the following

1. Weather App (Celsius to Fahrenheit Conversion)

First, let's derive the formula

The formula for converting Celsius (C) to Fahrenheit (F) is:

$$F = C \times \frac{9}{5} + 32$$

Now let's practice with an example:

a. Boiling Point of Water:

$$100^{\circ}\text{C} \rightarrow 100 \times \frac{9}{5} + 32 = 212^{\circ}\text{F} \text{ (Water boils at } 212^{\circ}\text{F in the Fahrenheit scale.)}$$

b. Edge Case:

-40°C → -40°F (This is a unique case where both scales match exactly!)

let's implement the conversion in Python

```
def celsius_to_fahrenheit(c):
```

```
    return c * 9/5 + 32
```

```
# Test Cases
```

```
print(celsius_to_fahrenheit(0)) # Output: 32.0 (Freezing)
```

```
print(celsius_to_fahrenheit(-40)) # Output: -40.0 (Edge Case)
```

2. Floating-Point Precision – A Common Pitfall in Computing

In digital computation, decimal numbers are not always stored exactly as we expect. This happens because computers use binary floating-point representation.

For instance, when you type the following code in python the output is false

```
print(0.1 + 0.2 == 0.3) # Output: False
```

This is because $0.1 + 0.2$ evaluates to 0.30000000000000004 .

This displayed result happens because computers represent numbers in **binary** (base-2), which does not perfectly match decimal (base-10) representation.

To handle this, we need to use a round function which works like this

Rounding functions (round(value, decimal places)).

So, we can rewrite the code as

```
print(round(0.1 + 0.2,1)== 0.3) # This time the output is true.
```

Understanding these precision issues helps us write reliable financial and scientific calculations when programming.

Learning Tasks

1. Learners practice solving samples addition and subtraction binary questions using shift operations
2. Learners practice with the weather app and the floating-point precision
3. Learners perform this task individual or as a group: Search for the formula of a compound interest and write a python code to calculate it.

Pedagogical Exemplars**Practice**

1. Teacher guides learners to solve samples on addition and subtraction binary questions using shift operations
2. Teacher demonstrates how Python code is applied to real-life problems using arithmetic operations

- Teacher supervises learners in the writing of the compound interest code (looking out for the floating-point precision in their codes).

Key Assessment: Discussion

DOK Level 2

- Explain why shift-and-add multiplication is considered more efficient than repeated addition.
(4 marks)
- Perform binary subtraction: $9 - 4$ using 4-bit two's complement method. Show all steps.
(10 marks)
- Why does $5.99 * 120$ sometimes return 718.8000000000001 instead of 718.8? (1 mark)

DoK Level 3

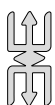
- You are designing a calculator that multiplies large numbers. Justify why using the shift-and-add method would be better than using repeated addition in your program.

PLC Session 3

45 minutes

Planning & Reviewing the Learning Plan

- Begin the session by recapping lessons from the previous year/session/week, focusing on how learning was applied.
- Use your subject specific app to explore the content before planning. Ask the app to
 - explain the week's concepts in a practical way that will make it easier for learners to understand
 - identify two or three common misconceptions learners may have on the week's content and how to address them using contexts familiar to Ghanaian learners. (NTS 3a, 3g and 3m).
- Use your subject specific app to plan your lesson. Ask the app to
 - suggest the most effective method for teaching the week's concepts to learners with diverse backgrounds.
 - suggest learning activities, differentiation and essential questions based on the method of teaching (NTS 3a-3q)
 - review your prepared learning plan and address any challenging issues you may have identified in your subject area (NTS 3a-3c).



Note

- Take note of the recap topics linked to Years 1 and 2 while preparing for your lesson.
- Refer to the Values Learning Community Handbook and link the values for the week in your lesson to ensure that learners are applying what they learn.

4. Plan the week's key assessment with your app

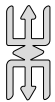
- a. The key assessment for the week is **discussion**. Chat with your app to plan this assessment, indicating what you and your learners will do before, during and after the discussion (NTS 3k-3q).

10 minutes

Content Exploration

5. As a subject group, select one problem or idea/term in the week's content that is challenging (not a routine procedural question, but one that requires conceptual understanding) and then

- a. use the app, ask it to solve the problem step by step and explain the reasoning behind each step (you may be assisted by a teacher who is strong in the content area)
- b. all teachers in the group work through a similar problem individually for 3–4 minutes
- c. the group then works through the problem together step by step
- d. highlight the most common errors made at each step and discuss (NTS 1c, 1e, 2c, 2e, 3e-3j).



Note

- This part is not just about 'How do I teach this?' but how do I teach it for learners to understand?
- If the group still shares the same content gap, use the app: ask it to solve the problem step by step and explain the reasoning behind each step.
- Problems/ideas discussed should be sourced from the Teacher Manual content, not invented separately. This keeps the content exploration directly connected to what teachers will deliver.

30 minutes

Enactment

6. Enact a teaching activity based on your learning plan (NTS 1a-1b, 1e-1g, 2c, 2e, 2f, 3c-3j and 3o).

- a. Colleagues observe with specific attention to clarity of concept explanation, use of familiar Ghanaian examples and how misconceptions are handled if they arise.
- b. After the enactment, ask for structured feedback from the group
 - i. was the concept explained in a way that a learner with no prior knowledge could follow?
 - ii. were the examples grounded in contexts familiar to Ghanaian learners?
 - iii. did any misconceptions surface and if so, how were they addressed?

5 minutes

Reflection

7. Reflect and share your views on the session. One thing that worked well, what did not work well and what you will do differently. (NTS 1a, 1b).
8. Identify a critical friend to observe and provide feedback on your lesson in relation to the PLC Session conducted (NTS 1f, 1g).

9. Remember to

- a. transfer your chats into your learning planner template.
- b. read your Teacher Manual and related Learner Material in preparation for the next session. Take note of the recap weeks, which are linked to Years 1 and 2 (NTS 3a).
- c. integrate National Values, GESI, SEL, and 21st century skills into your learning activities, assessment tasks, and rubrics/mark schemes.

Section Review

This section successfully advanced learners' understanding of computer architecture and network systems through practical problem-solving approaches. In this section, learners explored Boolean algebra applications, logic simplification, and CPU arithmetic operations, building foundational knowledge in computer architecture and data manipulation. Real-world applications included smart irrigation logic gates and system redundancy analysis. The three-week programme covered critical points and fail-safes, shift/rotation operations, and binary arithmetic using Python applications. By completion, learners developed essential skills in designing efficient, secure systems and troubleshooting hardware/software issues—competencies vital for continued technology studies and future careers in the field.

MARKING SCHEMES FOR THE KEY ASSESSMENTS

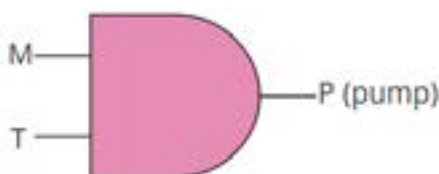
WEEK 1

Recap Assessment

Question 1

Expected Answer

A diagram showing M and T as inputs to an **AND gate**, with the output labelled as Pump (P).



- Correct use of AND gate (1 mark)
- Correct placement of inputs (M and T) (1 mark)
- Output labelled r correctly (Pump or P) (1 mark)

Total: 3 marks

Question 2

Expected Answer

Hardware redundancy adds an extra moisture sensor (Sensor B) in parallel. If Sensor A fails, Sensor B can still detect dryness, ensuring the system continues working.

Marking Scheme

- States definition of hardware redundancy (1 mark)
- Describes how it applies to moisture sensor failure (1 mark)
- Describes outcome (system continues to work) (1 mark)

Total: 3 marks**Question 3****Expected Answer**

A	B	T	P
0	0	0	0
0	0	1	0
0	1	0	0
0	1	1	1
1	0	0	0
1	0	1	1
1	1	0	0
1	1	1	1

Marking Scheme**Each correct row (0.5 marks $\times$ 8 = 4 marks)****Total: 4 marks****Question 4****Expected Answer**

Replace the AND gate with an OR gate so that if any one sensor detects movement, the alarm still sounds. Alternatively, they could use a fail-safe flip-flop to hold the alarm ON state once triggered.

Marking Scheme

- Suggests a valid redesign method (1 mark)
- Justifies how it prevents failure (2 marks)

Total: 3 marks**Question 5**

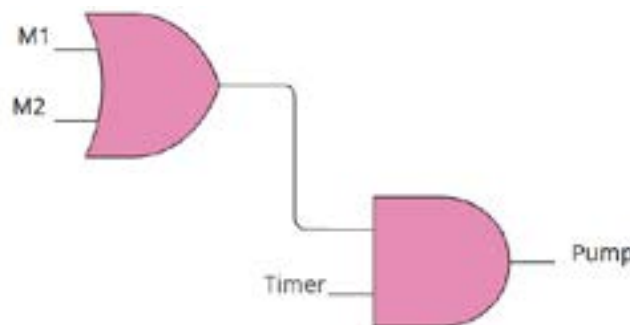
Criteria	Excellent (3)	Very Good (2)	Needs Improvement (1)
Critical Point Identification	Identifies 3 critical point in the circuit (e.g., power supply connection, main switch, key junction, ground connection)	Identifies 2 critical point in the circuit	Identifies 1 critical point in the circuit

Criticality Explanation	Explains why all the points are critical using technical reasons (e.g., controls power flow, connects multiple components, etc).	Explains why 2 points are critical with good technical reasoning and minor gaps.	Explanation why any the of the points are critical
Solution Proposal	Proposes a solution that directly addresses the critical point failure with implementation details (e.g., redundant components, monitoring system, protection circuit).	Proposes a solution with partial implementation details.	Proposes a solution without implementation details.

Question 6

Sample Solution

- a.
- Moisture Sensor Input – If stuck at 0, pump never activates.
 - AND Gate – If faulty, correct logic may not trigger the pump.
- b. Use two moisture sensors (M1, M2) and an OR gate to ensure that at least one working sensor detects dryness. The output of the OR gate goes to an AND gate with the Timer input.



Function:

If either M1 or M2 detects dryness (1), and Timer is 1, the pump activates. This design ensures the system works even if one sensor fails.

Rubric & Marking Scheme (10 Marks)

Criteria	Marks
a) Identification of critical points (1 pt each)	2
b) Explanation of identified critical point (1pt each)	2
c) Redundancy logic idea (clear concept using OR + AND)	3
d) Correct logic diagram with at most 4 inputs	2
e) Functional explanation	1

Criteria	Marks
Total	10

Question 7

Rubric

Criteria	Excellent (5)	Very Good (4)	Good (3)	Satisfactory (2)	Needs Improvement (1)
Truth Table Construction	Constructs a complete and flawless truth table with all 8 possible input combinations, correctly labels all columns (S1, S2, S3, Output)	Constructs a complete truth table with 6+ possible input combinations, correctly labels all columns (S1, S2, S3, Output)	Constructs a complete and flawless truth table with 4+ possible input combinations, correctly labels all columns (S1, S2, S3, Output)	Constructs a truth table with 2+ input combinations, correctly labels all columns (S1, S2, S3, Output)	Constructs a complete truth table with correct labels of all columns (S1, S2, S3, Output)
Boolean Expression Derivation	Correct expression that perfectly represents “at least 2 sensors” logic; appropriate form (e.g., $F = S1 \times S2 + S1 \times S3 + S2 \times S3$).	Correct expression with minor notation issues; represents required logic.	Expression with small errors but shows understanding of the voting logic.	Expression with significant errors; partially captures required logic	Incorrect expression that does not represent voting logic.
Fault Tolerance Proposal	Excellent proposal (e.g., redundant circuits, error detection) with specific implementation details for fire detection context.	Good proposal with clear explanation of implementation; addresses key failure modes.	Reasonable proposal with basic explanation; addresses some failure modes.	Basic proposal with limited details; minimal consideration of failures.	Inappropriate proposal; doesn't address fault tolerance.

Fault Tolerance Justification	analysing multiple failure modes; explains how proposal prevents false positives/negatives in fire detection.	Justification covering key failure modes; explains reliability improvements.	Adequate justification covering some failure modes; basic reliability discussion.	weak connection between relations	incorrect justification; fails to explain how proposal improves system.
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WEEK 2

Question 1

Sample Expected Answer

Logical shifts always fill empty bits with 0, while arithmetic shifts preserve the sign bit (leftmost bit) when shifting right.

Rubric

- 2 pts: Correctly state difference + example.
- 1 pt: Correct explanation in difference only
- 0 pts: Incorrect/no response.

Question 2

Solution Steps:

- Convert 26 to 8-bit binary: 00011010. (It's a positive number, so the sign bit is 0). – 1 mark
- Perform an arithmetic right shift by 1: The sign bit is '0'. When we shift right, a '0' is brought in on the left. The rightmost bit is discarded.
00011010 $\gg$ 1 $\rightarrow$ 00001101. – 1 mark
- 00001101 in decimal is 13. – 1 mark

Interpretation:

$26/2=13$. This confirms that an arithmetic right shift can perform division by 2 for positive numbers – 1 mark

Question 3

Answers

- (Doubling a number) $\rightarrow$ Logical Left Shift (or Arithmetic Left Shift)
- (Preserving negative signs) $\rightarrow$ Arithmetic Right Shift
- (Creating a password cipher) $\rightarrow$ Circular Shift
- (Dividing unsigned data) $\rightarrow$ Logical Right Shift

WEEK 3**Question 1****Rubric**

Criteria	Excellent (5)	Very Good (4)	Good (3)	Satisfactory (2)	Needs Improvement (1)
Method Explanation	Explains repeated addition (adding the same number multiple times) and shift-add (using shifts and adds based on binary digits)	Explains both methods with 3 steps: shift operations and additions for shift-add; repeated addition structure.	Describes both methods with 2 steps.	Describes only one method with one step	describes one method with no steps
Comparison of Steps Required	Explains with a specific example (e.g., 13×7) that repeated addition needs more steps (13 additions) than shift-add (3-4 operations).	Explains with an example that shift-add needs fewer steps, with 1 counting errors	Explains with an example that shift-add needs fewer steps, with 2 counting errors	Explains with an example that shift-add needs fewer steps, with 3 counting errors	Explains with an example that shift-add needs fewer steps, with 4 counting errors

Question 2**Expected Answer**

Convert: $9 = 1001$, $4 = 0100$

Two's complement of 4:

Invert $0100 \rightarrow 1011$

Add 1 $\rightarrow 1011 + 1 = 1100$

Add: $1001 + 1100 = 1\ 0101$

Discard overflow $\rightarrow$ Result: 0101

Decimal: $0101 = 5$

Marking Scheme:

Step	Marks
Correct binary conversion of 9 and 4	1
Correct two's complement of 4	1

Step	Marks
Correct binary addition and discard overflow	1
Correct interpretation of result in decimal	1
Total	4

Question 3

Answer: Binary floating-point cannot precisely represent decimal fractions.

Question 4

Criteria	Excellent (5)	Very Good (4)	Good (3)	Satisfactory (2)	Needs Improvement (1)
Explanation	Explains that shift-and-add requires fewer operations than repeated addition (n operations) with a specific example using large numbers.	Explains shift-and-add requires fewer operations than repeated addition with an example using smaller numbers.	Explains shift-and-add requires fewer operations than repeated addition without examples	Omits 1 technical terms (e.g.: requires fewer, repeated addition) in the explanation without example	Omits 1 technical terms (e.g.: requires fewer, repeated addition) in the explanation without example

SECTION 2: SYSTEM SOFTWARE COMPONENTS

STRAND: COMPUTER ARCHITECTURE & ORGANISATION

Sub-Strand: Computer Hardware and Software

Content Standard: Demonstrate knowledge and understanding of components of Computer Hardware and types of Software.

Week 4

Learning Outcome: *Explain the roles of operating systems and utility software as components of system software, demonstrating an understanding of their functions.*

Week 5

Learning Outcome: *Perform the installation and management of an operating system, showcasing proficiency in the process.*

INTRODUCTION AND SECTION SUMMARY

This section explores the critical role of system software in managing computer hardware and enabling application software functionality. Learners will examine operating systems and utility software as essential components that serve as intermediaries between users and hardware. Through practical exploration and real-world examples, learners will develop a comprehensive understanding of how these components work together to provide essential services, manage resources, and enhance system performance and security in various computing environments.

The focal area covered are

- Week 4: System Software (Operating Systems and Utility Software)
- Week 5: Operating System Installation, Configuration and Management

PEDAGOGICAL SUMMARY

In this section, interactive discussion builds on prior software knowledge while visual demonstrations bring system software concepts to life. Through practical demonstrations of operating system functions using Task Manager, File Explorer and Device Manager, learners observe the critical intermediary role these components play. Real-time demonstrations of process management, file operations and hardware interaction help learners visualise abstract concepts.

ASSESSMENT SUMMARY

Depth of Knowledge (DOK) is employed in the assessment of learners to enhance the quality, validity and fairness of assessments while promoting deeper learning and critical thinking

skills. Various forms of assessments are conducted to determine the learners' performance on the concepts that will be taught under this section. Teachers are entreated to administer these assessments and the record as hinted above for onward submission into the Student Assessment Portal (SAP).

Weeks	Indicator	DoK Level	Assessment Mode
4	Demonstrate the roles of Operating Systems and Utility Software as components of System Software.	2	Multiple Choice Questions
5	Demonstrate the process of installing and managing an operating system.	2	Class Exercise

WEEK 4

Learning Indicator: *Demonstrate the roles of Operating Systems and Utility Software as components of System Software*

Recap Weeks

Year 1	Week 5: Identify and explain the functions of operating systems. Week 6: Explain the types of software and their functions.
Year 2	Week 5: Compare different types of operating systems and their applications. Week 6: Demonstrate basic system administration tasks

FOCAL AREA: **SYSTEM SOFTWARE (OPERATING SYSTEMS AND UTILITY SOFTWARE)**

System software serves as an intermediary between computer hardware and the end user, providing essential services that enable application software to run effectively. This focal area explores the two main components of system software: operating systems and utility software, their functions, and their importance in computing environments.

KEY CONCEPTS

1. System Software (Definition and Purpose)

- System software is a type of computer software designed to run and manage computer hardware and provide a platform for application software.
- It acts as an intermediary between hardware components and the user.
- System software is essential for the functioning of the computer system.

2. Categories of System Software

- Operating Systems (OS)
- Utility Software
- Firmware

3. Characteristics of System Software

- Runs in the background
- Installed when the computer is set up
- Written in low-level languages
- Hardware-oriented
- Controls the basic functions of a computer

OPERATING SYSTEMS

An operating system is software that manages computer hardware and software resources. It provides common services for computer programs and acts as an interface between users and hardware.

Primary Functions of Operating Systems (OS)

1. It controls the execution of programs and allocates processor time.
2. OS allocates and deallocates memory space as needed.
3. It organises and tracks files and directories on storage devices.
4. OS controls input/output devices and their drivers.
5. It provides a user interface (GUI or CLI) for users to interact seamlessly with the computer system.
6. It controls access to system resources and protects data.

Types of Operating Systems

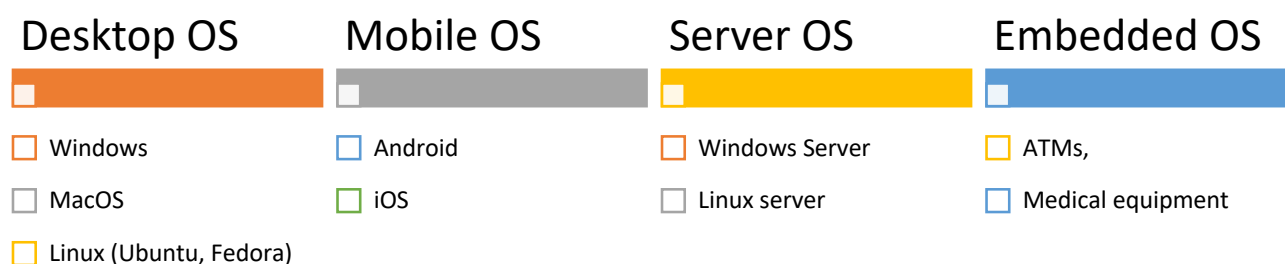


Figure 2.1 Types of Operating Systems

Common Operating Systems in Ghana

1. Windows dominates in government offices, schools and businesses
2. Android is the most common mobile OS in the country
3. Linux is used in some educational institutions and server environments
4. iOS devices are less common but more present in urban areas like Accra and Kumasi.

UTILITY SOFTWARE

Utility software is designed to help analyse, configure, optimise and maintain a computer system. It performs specific tasks related to managing computer resources. It enhances the capabilities of the operating system.

Categories of Utility Software

1. Disk Management Utilities

- Disk cleanup tools: Remove unnecessary files to free up space
- Disk defragmenters: Reorganise file fragments to improve performance
- Disk checkers: Scan for and repair disk errors
- Partition managers: Create, resize, and manage disk partitions

Examples: Disk Cleanup (Windows), Disk Utility (macOS)

2. File Management Utilities

- File compression tools: Reduce file size for storage or transmission
- File synchronisation tools: Keep files updated across multiple devices
- File recovery software: Retrieve deleted or corrupted files

Examples: WinZip, 7-Zip, Recuva

3. Security Utilities

- Antivirus software: Detect and remove malicious software
- Firewalls: Monitor and control network traffic
- Anti-spyware: Prevent unauthorised data collection

Examples: Avast, AVG, Windows Defender

4. System Optimisation Utilities

- Registry cleaners: Fix errors in the system registry
- System monitors: Track computer performance
- Startup managers: Control programs that run at startup

Examples: CCleaner, Advanced SystemCare

5. Backup Utilities

- Create copies of important data for recovery purposes
- Schedule regular automated backups

Examples: Windows Backup, Time Machine (macOS)

Relationship Between Operating Systems and Utility Software

1. Complementary Functions

- a. Operating systems provide the foundation for computer operation
- b. Utility software enhances, extends or complements OS functionality
- c. Together they form a complete system software environment

2. Integration Points

- a. Many modern operating systems include built-in utility software
- b. Third-party utilities often integrate with OS functions
- c. Some utilities require specific OS permissions to function properly

3. Dependency Relationships

- a. Utilities depend on the OS for hardware access
- b. The OS may rely on utilities for enhanced functionality

- c. Both must be compatible with the hardware platform

Practical Applications in Ghana

1. Educational Settings

- School computer labs using Windows OS with antivirus protection
- Universities implementing disk management utilities to maintain lab computers
- Educational institutions using backup utilities to protect academic records

2. Business Applications

- Small businesses in Ghana using file compression to share large documents
- Banks implementing security utilities to protect financial data
- Local companies using system optimisation tools to extend the life of older computers

3. Personal Computing

- Mobile phone users managing storage with built-in utilities
- Home computer users protecting against malware common in Ghana
- Learners using file recovery tools to retrieve lost assignments

Learning Tasks

1. Recap

Learners participate in a brief discussion about their experiences with different operating systems based on contents from year 1 and 2.

2. Learners observe and take notes on the demonstrations.

3. Exploration

- a. In groups, learners explore different operating systems available in the computer lab or through screenshots:
 - i. Windows
 - ii. Linux (if available)
 - iii. Android/iOS (if mobile devices are available)
- b. Each group documents the user interface, features and functions of their assigned OS.
- c. Groups share their findings with the class, highlighting similarities and differences.

Pedagogical Exemplars

1. The teacher uses discussion to review prior learning about types of software from Years 1 and 2.
2. The teacher introduces the concept of system software and its main categories.
3. The teacher explains the core functions of operating systems with visual aids and examples.

4. For each function (process management, memory management, etc.), the teacher demonstrates:
 - a. How it works in principle.
 - b. How users interact with it.
 - c. What happens when this function fails.
5. The teacher again demonstrates how an operating system acts as an intermediary between hardware and applications using:
 - a. Task Manager or Activity Monitor to show running processes
 - b. File Explorer or Finder to demonstrate file management
 - c. Device Manager to show hardware management
 - d. User account settings to demonstrate security features
6. The teacher discusses how these functions are relevant in Ghanaian computing contexts (e.g., managing limited resources in school labs).

Key Assessment: Multiple Choice Questions

DoK Level 2

1. Which of the following is NOT a function of an operating system?
 - A. Memory management
 - B. File compression
 - C. Device management
 - D. User interface provision
2. What type of utility software would you use to create a backup of your important files?
 - A. Disk defragmenter
 - B. Antivirus software
 - C. Backup utility
 - D. File compression tool
3. Which component of system software communicates directly with hardware devices?
 - A. Application software
 - B. Device drivers
 - C. File manager
 - D. User interface
4. What is the primary purpose of disk defragmentation utility software?
 - A. Remove viruses from the hard drive
 - B. Organise file fragments for faster access

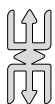
- C. To create backups of important files
 - D. To encrypt sensitive data
5. Which of the following best describes the relationship between operating systems and utility software?
- A. They are completely separate and independent
 - B. Utility software replaces operating system functions
 - C. Utility software enhances and extends operating system functionality
 - D. Operating systems are a type of utility software

PLC Session 4

45 minutes

Planning & Reviewing the Learning Plan

1. Begin the session by recapping lessons from the previous year/session/week, focusing on how learning was applied.
2. Use your subject specific app to explore the content before planning. Ask the app to
 - a. explain the week's concepts in a practical way that will make it easier for learners to understand
 - b. identify two or three common misconceptions learners may have on the week's content and how to address them using contexts familiar to Ghanaian learners. (NTS 3a, 3g and 3m).
3. Use your subject specific app to plan your lesson. Ask the app to
 - a. suggest the most effective method for teaching the week's concepts to learners with diverse backgrounds.
 - b. suggest learning activities, differentiation and essential questions based on the method of teaching (NTS 3a-3q)
 - c. review your prepared learning plan and address any challenging issues you may have identified in your subject area (NTS 3a-3c).



Note

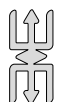
- Take note of the recap topics linked to Years 1 and 2 while preparing for your lesson.
- Refer to the Values Learning Community Handbook and link the values for the week in your lesson to ensure that learners are applying what they learn.

4. Plan the week's key assessment with your app
 - a. The key assessment for the week is **multiple choice questions**. Chat with your app to plan this assessment, indicating what you and your learners will do before, during and after the assessment (NTS 3k-3q).

10 minutes

Content Exploration

5. As a subject group, select one problem or idea/term in the week's content that is challenging (not a routine procedural question, but one that requires conceptual understanding) and then
 - a. use the app, ask it to solve the problem step by step and explain the reasoning behind each step (you may be assisted by a teacher who is strong in the content area)
 - b. all teachers in the group work through a similar problem individually for 3–4 minutes
 - c. the group then works through the problem together step by step
 - d. highlight the most common errors made at each step and discuss (NTS 1c, 1e, 2c, 2e, 3e-3j).



Note

- This part is not just about 'How do I teach this?' but how do I teach it for learners to understand?
- If the group still shares the same content gap, use the app: ask it to solve the problem step by step and explain the reasoning behind each step.
- Problems/ideas discussed should be sourced from the Teacher Manual content, not invented separately. This keeps the content exploration directly connected to what teachers will deliver.

30 minutes

Enactment

6. Enact a teaching activity based on your learning plan (NTS 1a-1b, 1e-1g, 2c, 2e, 2f, 3c-3j and 3o).
 - a. Colleagues observe with specific attention to clarity of concept explanation, use of familiar Ghanaian examples and how misconceptions are handled if they arise.
 - b. After the enactment, ask for structured feedback from the group
 - i. was the concept explained in a way that a learner with no prior knowledge could follow?
 - ii. were the examples grounded in contexts familiar to Ghanaian learners?
 - iii. did any misconceptions surface and if so, how were they addressed?

5 minutes

Reflection

7. Reflect and share your views on the session. One thing that worked well, what did not work well and what you will do differently. (NTS 1a, 1b).
8. Identify a critical friend to observe and provide feedback on your lesson in relation to the PLC Session conducted (NTS 1f, 1g).
9. Remember to
 - a. transfer your chats into your learning planner template.
 - b. read your Teacher Manual and related Learner Material in preparation for the next session. Take note of the recap weeks, which are linked to Years 1 and 2 (NTS 3a).
 - c. integrate National Values, GESI, SEL, and 21st century skills into your learning activities, assessment tasks, and rubrics/mark schemes.

WEEK 5

Learning Indicator: *Demonstrate the process of installing and managing an operating system*

Recap Weeks

Year 1	Week 5: Identify and explain the functions of operating systems. Week 6: Explain the types of software and their functions.
Year 2	Week 5: Compare different types of operating systems and their applications. Week 6: Demonstrate basic system administration tasks Week 7-8: Configure basic system settings and preferences

FOCAL AREA: OPERATING SYSTEM INSTALLATION, CONFIGURATION AND MANAGEMENT

1. OS Components and Architecture

An operating system (OS) is the software that manages a computer's hardware and software. It ensures everything runs smoothly and allows users to interact with the system. Below are its key components:

- a. **Kernel:** The heart of the OS, responsible for managing hardware resources such as the CPU, memory and storage.
- b. **Shell:** Acts as the bridge between the user and the OS. It can be a Graphical User Interface (GUI) with windows and icons or a Command Line Interface (CLI) where users type commands.
- c. **File Systems:** Organises and stores files efficiently on storage devices, ensuring easy access and retrieval. Common examples include:

FAT32 (File Allocation Table 32): Universal cross-platform compatibility across Windows, Mac, and Linux, but lacks journaling and cannot store individual files larger than 4 GB.

NTFS (New Technology File System): Default for Windows; provides robust file permissions, compression, and journaling (logging changes to recover quickly from crashes and power loss).

ext4 (Fourth Extended Filesystem): Standard high-performance journaling file system for Linux distributions, engineered for reliability and minimal fragmentation.

APFS (Apple File System): Default for modern macOS and iOS; optimized specifically for solid-state drives (SSDs) with features like instant file cloning, crash-safe metadata snapshots, and native encryption.

- d. **System Services and Processes:** Background tasks that keep the OS running, such as managing printers, handling network connections and running applications.
- e. **Device Drivers:** Special software that allows the OS to communicate with hardware like keyboards, printers and graphics cards. Without drivers, devices would not function correctly.

2. OS Selection Considerations

When selecting an operating system (OS), several factors come into play to ensure it meets the user's needs. Here are some key considerations:

- a. **Hardware Compatibility & Requirements:** Different OSes have varying system requirements. A lightweight OS like Linux might run smoothly on older hardware, while newer versions of Windows or macOS may require more RAM and processing power.
- b. **Software Compatibility:** The OS must support essential applications. For example, businesses using Microsoft Office and industry-specific software may require Windows, while creative professionals may prefer macOS for design tools.
- c. **Purpose:** The OS should align with its intended use:
 - i. Personal Use – Entertainment, social media and general tasks (Windows, macOS, Linux).
 - ii. Business – Productivity tools, security, and collaboration (Windows, macOS, Linux).
 - iii. Specialised Applications – Engineering, gaming, programming, or design (While modern operating systems offer versatile cross-platform environments supporting development, productivity, and multimedia creation across the board, each retains traditional ecosystem strengths—such as Windows in broad hardware compatibility and commercial gaming, Linux in server management and infrastructure tooling, and macOS in color-calibrated digital media production).
- d. **Cost Considerations:** There are two main types:
 - i. Proprietary OS (e.g., Windows, macOS) – Requires purchase or licensing.
 - ii. Open-source OS (e.g., Linux) – Free to use with community support but may require technical knowledge.
- e. **Support Availability in Ghana:** The availability of repair services, troubleshooting guides, and software support affects usability. Windows has strong technical support in Ghana, while Linux and macOS may have fewer local specialists.
- f. **Prevalence in the Local Job Market:** Windows is the dominant OS in Ghanaian workplaces, especially in offices, banks and educational institutions. Learning Windows can be beneficial for job seekers, while tech professionals may find Linux useful for specialised roles.

3. Pre-Installation Planning

a. Hardware Assessment

Before installing an OS, it is essential to assess the hardware to ensure compatibility and optimal performance. Here are the key steps in hardware assessment:

- i. **System Requirements Verification** – Check whether the computer meets the OS's minimum and recommended specifications. Factors include processor speed, RAM capacity, and available storage.

- ii. **Compatibility Checking** – Ensure that all hardware components, such as graphics cards, network adapters, and peripherals, are compatible with the OS. Some older hardware may require drivers or special configurations.
- iii. **Hardware Inventory** – Take note of existing hardware, including internal components (CPU, RAM, hard drives) and external devices (printers, scanners, USB drives). This helps in troubleshooting and upgrading later.
- iv. **Storage Requirements & Partitioning Strategy** – Determine available disk space and whether additional storage is needed. Plan partitions to separate system files, personal data and backups. A common setup includes a primary partition for the OS and secondary partitions for files and recovery tools.

b. Backup Strategies Before Installation

Backing up data is an important step before installing or upgrading an operating system. Here is how to ensure data safety:

- i. **Data Backup Methods & Tools** – Use external drives, cloud storage, or backup software to save important files. Common tools include Google Drive, OneDrive, and Acronis True Image.
- ii. **Creating System Recovery Media** – Prepare a bootable USB or recovery disk that allows restoration if the installation encounters issues.
- iii. **Documenting Existing Configurations** – Record settings, installed applications, and network configurations to simplify post-installation setup.
- iv. **Testing Backups Before Proceeding** – Verify that backup files are accessible and functional to prevent data loss.

c. Installation Methods

Different installation approaches suit various needs like:

- i. **Clean Installation vs. Upgrade:**
 - **Clean Installation:** Wipes all data and installs a fresh OS copy, best for eliminating bugs or switching operating systems.
 - **Upgrade:** Retains existing files and settings while installing a newer OS version.
- ii. **Dual-Boot Configurations:** Allows running multiple OSes on one device, enabling users to switch between Windows and Linux, for example.
- iii. **Virtualisation Options:** Runs an OS within another OS using software like VirtualBox or VMware, useful for testing or using different applications.
- iv. **Network-Based Installation:** Installs the OS over a network, ideal for businesses managing multiple systems without individual installations.
- v. **Recovery Partition Installation:** Some devices come with a built-in partition that allows reinstalling the OS without external media.

The pre-installation planning workflow is summarised in Figure 2.2.

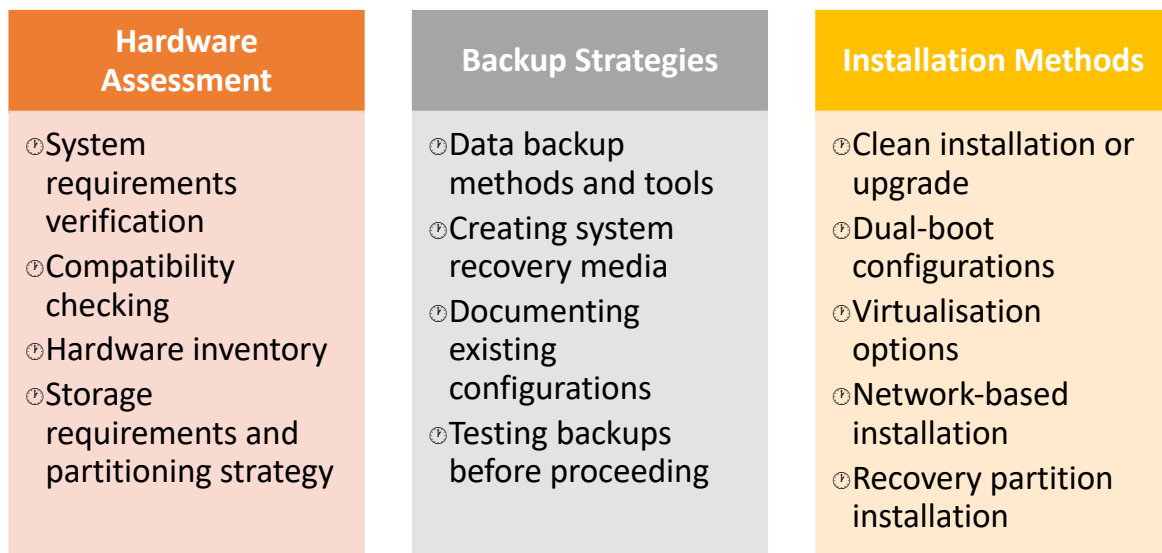


Figure 2.2 Pre-installation Planning Summary

4. Operating System Installation Process

Installing an OS involves several key stages, which ensures that the system is properly set up. Below is a step-by-step breakdown:

a. Installation Media Preparation

- Creating Bootable USB Drives – Use tools like Rufus or the Windows Media Creation Tool to make a USB drive bootable for installation.
- Verifying Media Integrity – Ensure the installation files are not corrupted by checking hashes or using built-in verification tools.
- Accessing and Configuring BIOS/UEFI Settings – Enter BIOS/UEFI (usually by pressing F2, F12, or DEL at startup) to adjust boot settings.
- Boot Sequence Configuration – Set the USB or installation disk as the primary boot device before restarting the system.

b. Installation Steps

- Booting from Installation Media – Start the computer using the prepared USB or disk.
- Language and Region Selection – Choose preferred language, keyboard settings, and time zone.
- Disk Partitioning and Formatting – Allocate storage space, format partitions, and select where the OS will be installed.
- Installation Type Selection – Choose between a clean installation or an upgrade based on user needs.
- User Account Creation – Set up administrator credentials and other necessary accounts.
- Network Configuration – Connect to Wi-Fi or Ethernet and configure settings for updates and online services.

- vii. **Installation Completion and Initial Boot** – Restart the system and finalise basic setups.

c. **Post-Installation Tasks**

- i. **Driver Installation and Updates** – Ensure hardware functions properly by updating essential drivers.
- ii. **System Updates and Patches** – Install necessary updates to improve security and stability.
- iii. **Basic Security Configuration** – Set up firewalls, antivirus software, and user permissions for safety.
- iv. **Software Installation** – Install required programs, including productivity tools or industry-specific software.
- v. **Data Restoration from Backups** – Recover files from previously backed-up data.
- vi. **System Verification and Testing** – Confirm smooth functionality by checking drivers, network connections, and system performance.

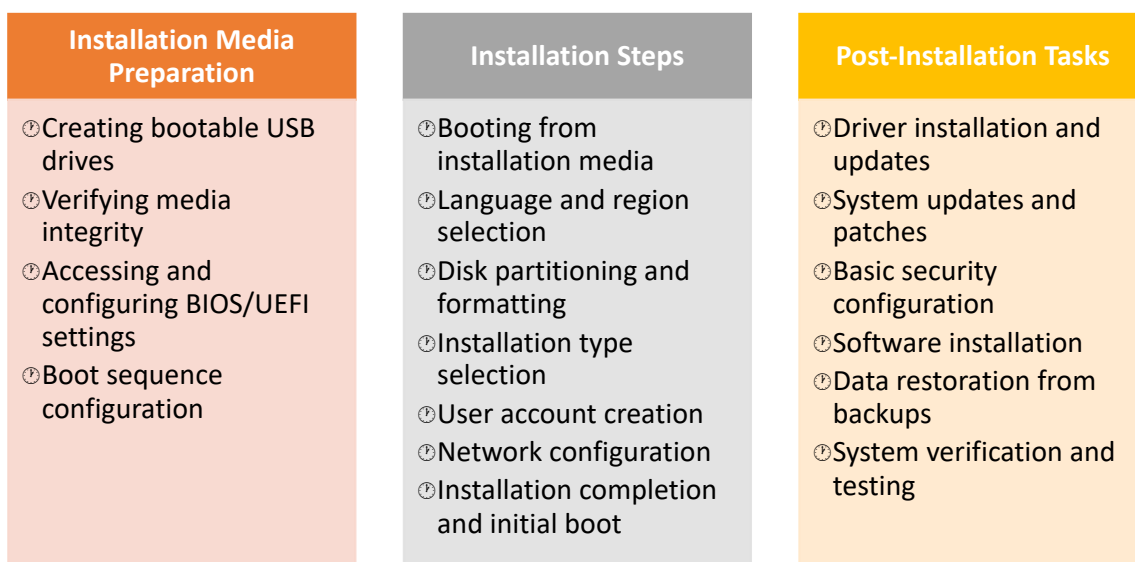


Figure 2.3 Summary of Installation Process

5. **Operating System Management**

Managing an operating system effectively ensures security, performance and stability. Below are key aspects of OS management:

a. **User Account Management**

- i. **Creating and Managing User Accounts** – Set up multiple accounts for different users with appropriate access levels.
- ii. **Setting Permissions and Access Controls** – Restrict or grant access to files, applications and system settings based on user roles.
- iii. **Implementing Password Policies** – Enforce strong passwords and regular changes to enhance security.
- iv. **Group Management** – Organise users into groups (e.g., administrators, standard users) for easier access control and permission assignments.

b. System Maintenance

- i. Regular Updates and Patches – Keep the OS secure and stable by installing updates and security patches.
- ii. Disk Cleanup and Defragmentation – Remove unnecessary files and optimise storage for faster performance.
- iii. Startup Program Management – Disable or manage programs that launch at startup to improve boot speed.
- iv. Performance Monitoring and Optimisation – Use tools to track system performance and improve efficiency.
- v. Backup Scheduling and Verification – Automate backups and check their integrity to prevent data loss.

c. Software Management

- i. Installing and Uninstalling Applications – Properly add or remove software to maintain system stability.
- ii. Managing Updates for Applications – Keep software up to date for security and improved functionality.
- iii. Troubleshooting Software Issues – Identify and fix application errors and crashes.
- iv. Software Licensing Management – Ensure software is legally licensed and compliant with usage agreements.

d. System Monitoring and Troubleshooting

- i. Using Built-in Diagnostic Tools – Utilise system utilities like Task Manager and Resource Monitor for issue detection.
- ii. Event Log Analysis – Check system logs to track errors and performance trends.
- iii. Resource Monitoring (CPU, Memory, Disk, Network) – Observe system resource usage to prevent bottlenecks.
- iv. Common Problem Identification and Resolution – Diagnose and fix frequent issues like slow performance or connectivity failures.
- v. System Restores and Recovery Options – Use restores points or recovery tools to fix major issues or revert changes.
- vi. Proper OS management enhances system reliability and ensures smooth operation.

User Account Management	System Maintenance	Software Management	System Monitoring and Troubleshooting
🕒 Creating and managing user accounts 🕒 Setting permissions and access controls 🕒 Implementing password policies 🕒 Group management	🕒 Regular updates and patches 🕒 Disk cleanup and defragmentation 🕒 Startup program management 🕒 Performance monitoring and optimisation 🕒 Backup scheduling and verification	🕒 Installing and uninstalling applications 🕒 Managing updates for applications 🕒 Troubleshooting software issues 🕒 Software licensing management	🕒 Using built-in diagnostic tools 🕒 Event log analysis 🕒 Resource monitoring (CPU, memory, disk, network) 🕒 Common problem identification and resolution 🕒 System restores and recovery options

Figure 2.4: Summary of Operating System Management

6. Advanced Management

Managing an operating system at an advanced level involves key administrative tasks that enhance security, efficiency and remote access. Below are the essential topics covered:

a. Command Line Administration

- i. Basic Command Syntax and Structure – Understanding command formats for efficient task execution in the command line.
- ii. File and Directory Management Commands – Using commands like **mkdir**, **cp**, **mv**, **ls** and **rm** for organising and handling files.
- iii. System monitoring utilities categorised by platform:
 - Linux / macOS (Bash/POSIX): **uname** (system architecture/kernel), **df** (disk space usage), and **top** (real-time process and CPU/memory activity)
 - Windows (Command Prompt / PowerShell): **systeminfo**, **tasklist**, or modern PowerShell cmdlets such as **Get-ComputerInfo** (legacy: **wmic**).
- iv. Network Configuration Commands – Setting up connections with **ipconfig**, **ping**, **tracert** and **netstat**.
- v. Script Automation Basics – Writing simple batch files or shell scripts to automate repetitive tasks.

b. Security Management

- i. Built-in Security Features Configuration – Adjusting security settings like user access control, group policies and secure boot options.
- ii. Firewall Settings – Configuring firewalls to block unauthorised network access using Windows Defender Firewall or iptables in Linux.
- iii. Malware Protection – Using antivirus software, security patches and behavioural analysis tools to detect and prevent threats.
- iv. Encryption Options – Encrypting data using tools like BitLocker (Windows), FileVault (macOS), or LUKS (Linux).
- v. Security Best Practices – Implementing strong passwords, enabling multi-factor authentication and conducting security audits.

c. Remote Management

- i. Remote Desktop Access Configuration – Setting up Remote Desktop Protocol (RDP) or SSH for managing computers remotely.
- ii. Remote Administration Tools – Using software like TeamViewer, AnyDesk, or Microsoft Remote Desktop to control devices remotely.
- iii. Secure Remote Connection Protocols – Implementing VPNs and SSH tunnels for encrypted remote connections.
- iv. Mobile Device Management Considerations – Managing OS security and configurations for mobile devices using MDM solutions like Microsoft Intune.

d. Virtualisation Concepts

- i. Virtual Machine Creation and Management – Using tools like VMware, VirtualBox, or Hyper-V to create virtual environments.
- ii. Benefits of Virtualisation – Running multiple OS instances, improving security and optimising resource usage.
- iii. Resource Allocation – Assigning CPU, memory and storage for efficient virtualisation performance.
- iv. Snapshot and Backup Strategies – Saving VM states before updates and maintaining recoverable backups.

Command Line Administration	Security Management	Remote Management	Virtualisation Concepts
• Basic command syntax and structure • File and directory management commands • System information commands • Network configuration commands • Script automation basics	• Built-in security features configuration • Firewall settings • Malware protection • Encryption options • Security best practices	• Remote desktop access configuration • Remote administration tools • Secure remote connection protocols • Mobile device management considerations	• Virtual machine creation and management • Benefits of virtualisation • Resource allocation • Snapshot and backup strategies

Figure 2.5 Summary of Advanced Management

Learning Tasks

1. In groups, learners discuss and document:
 - a. OS preferences based on different scenarios (home use, business, education)
 - b. Factors influencing OS selection in Ghana (cost, support, compatibility)
 - c. Common challenges in OS management in the Ghanaian context
2. Groups share their findings with the class.

3. If resources permit, learners practice creating installation media and install an OS on a laptop.
4. If not then they can watch a visual aid presentation/video of the installation process.
5. Learners document the steps and ask questions throughout the demonstration.
6. In groups, learners create a comprehensive post-installation checklist for a specific environment (school lab, internet café, small business office).
7. Groups share their checklists and discuss differences based on environment needs.

Pedagogical Exemplars

1. The teacher presents an overview of current operating systems with examples of their use in Ghana:
 - a. Windows in government offices and businesses
 - b. Linux in server environments and educational institutions
 - c. Android and iOS in mobile computing
2. The teacher circulates to provide guidance and feedback on learners' OS preferences.
3. The teacher demonstrates the pre-installation planning process:
 - Hardware assessment using system information tools
 - Creating a complete backup strategy
 - Installation media preparation
4. The teacher explains different installation scenarios:
 - a. Clean installation
 - b. Upgrade installation
 - c. Dual-boot configuration
 - d. Virtualised installation
5. The teacher demonstrates how to:
 - a. Download OS installation files from official sources
 - b. Verify file integrity
 - c. Create bootable USB installation media
 - d. Configure BIOS/UEFI settings for booting from external media
6. If hands-on practice is not possible, the teacher provides a detailed walkthrough with visual aids.
7. The teacher discusses common issues encountered during media preparation and their solutions.
8. The teacher demonstrates a complete OS installation process:
 - a. Booting from installation media

- b. Navigating installation screens
 - c. Partitioning and formatting drives
 - d. Selecting installation options
 - e. Creating user accounts
 - f. Completing installation and initial setup
9. The teacher explains key decision points and best practices throughout the process.
 10. If possible, this should be done on actual hardware; otherwise, using virtualisation software or detailed videos/screenshots.
 11. The teacher demonstrates essential post-installation tasks:
 - a. Driver installation and updates
 - b. System updates
 - c. Basic security configuration
 - d. Software installation
 - e. Performance optimisation
 12. The teacher provides feedback and additional considerations on learners' checklist.

Key Assessment: Class Exercise

DoK Level 2

1. When preparing to install Windows on a computer, which step should be completed first?
(1 mark)
 - A. Format the hard drive
 - B. Backup existing data
 - C. Update the BIOS
 - D. Create a user account
2. Which of the following is the most secure post-installation configuration step after installing Windows?

(1 mark)

- A. Changing the desktop background
- B. Creating a standard user account for daily use
- C. Disabling the Windows firewall
- D. Installing all available Windows updates

DoK Level 4

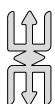
3. Prepare an installation plan and demonstrate how to install Windows on a computer. After the installation write an explanation of 2 post-installation configuration tasks that must be made.

PLC Session 5

45 minutes

Planning & Reviewing the Learning Plan

1. Begin the session by recapping lessons from the previous year/session/week, focusing on how learning was applied.
2. Use your subject specific app to explore the content before planning. Ask the app to
 - a. explain the week's concepts in a practical way that will make it easier for learners to understand
 - b. identify two or three common misconceptions learners may have on the week's content and how to address them using contexts familiar to Ghanaian learners. (NTS 3a, 3g and 3m).
3. Use your subject specific app to plan your lesson. Ask the app to
 - a. suggest the most effective method for teaching the week's concepts to learners with diverse backgrounds.
 - b. suggest learning activities, differentiation and essential questions based on the method of teaching (NTS 3a-3q)
 - c. review your prepared learning plan and address any challenging issues you may have identified in your subject area (NTS 3a-3c).



Note

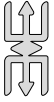
- Take note of the recap topics linked to Years 1 and 2 while preparing for your lesson.
- Refer to the Values Learning Community Handbook and link the values for the week in your lesson to ensure that learners are applying what they learn.

4. Plan the week's key assessment with your app
 - a. The key assessment for the week is **class exercise**. Chat with your app to plan this assessment, indicating what you and your learners will do before, during and after the exercise (NTS 3k-3q).

10 minutes

Content Exploration

5. As a subject group, select one problem or idea/term in the week's content that is challenging (not a routine procedural question, but one that requires conceptual understanding) and then
 - a. use the app, ask it to solve the problem step by step and explain the reasoning behind each step (you may be assisted by a teacher who is strong in the content area)
 - b. all teachers in the group work through a similar problem individually for 3–4 minutes
 - c. the group then works through the problem together step by step
 - d. highlight the most common errors made at each step and discuss (NTS 1c, 1e, 2c, 2e, 3e-3j).



Note

- This part is not just about ‘How do I teach this?’ but how do I teach it for learners to understand?
- If the group still shares the same content gap, use the app: ask it to solve the problem step by step and explain the reasoning behind each step.
- Problems/ideas discussed should be sourced from the Teacher Manual content, not invented separately. This keeps the content exploration directly connected to what teachers will deliver.

30 minutes

Enactment

6. Enact a teaching activity based on your learning plan (NTS 1a-1b, 1e-1g, 2c, 2e, 2f, 3c-3j and 3o).
 - a. Colleagues observe with specific attention to clarity of concept explanation, use of familiar Ghanaian examples and how misconceptions are handled if they arise.
 - b. After the enactment, ask for structured feedback from the group
 - i. was the concept explained in a way that a learner with no prior knowledge could follow?
 - ii. were the examples grounded in contexts familiar to Ghanaian learners?
 - iii. did any misconceptions surface and if so, how were they addressed?

5 minutes

Reflection

7. Reflect and share your views on the session. One thing that worked well, what did not work well and what you will do differently. (NTS 1a, 1b).
8. Identify a critical friend to observe and provide feedback on your lesson in relation to the PLC Session conducted (NTS 1f, 1g).
9. Remember to
 - a. transfer your chats into your learning planner template.
 - b. read your Teacher Manual and related Learner Material in preparation for the next session. Take note of the recap weeks, which are linked to Years 1 and 2 (NTS 3a).
 - c. integrate National Values, GESI, SEL, and 21st century skills into your learning activities, assessment tasks, and rubrics/mark schemes.

(14 marks)

Section Review

This section successfully developed learners’ understanding of system software components, particularly operating systems and utility software. Through interactive discussions and practical demonstrations, learners explored how these critical components serve as intermediaries between users and hardware. The section covered essential functions including process management, memory allocation, file organisation, and security features.

Learners gained practical experience with system tools like Task Manager, File Explorer, and Device Manager, learning to analyse and troubleshoot common issues.

Marking schemes for the key assessments

WEEK 4

Answers

1. B
2. C
3. B
4. B
5. C

WEEK 5

1. B
2. D
- 3.

Criteria	Excellent (5)	Very Good (4)	Good (3)	Satisfactory (2)	Needs Improvement (1)
Pre-installation Preparation	Lists all 5 preparation steps (backup data, check system requirements, create bootable media, BIOS settings, partition planning) with explanation	Lists 4 preparation steps with explanation	Lists 3 preparation steps with explanation	Lists 2 preparation steps with explanation	Lists only 1 preparation step with explanation
Installation Steps Sequence	Demonstrates all 8 installation steps in perfect sequential order	Demonstrates 6-7 installation steps in correct sequence	Demonstrates 5-6 installation steps in correct order	Demonstrates 4-5 installation steps	Demonstrate fewer than 4 steps

Post-installation Configuration	-	Explains 2 essential post-installation tasks (driver updates, Windows activation, security set-up, etc.) with step-by-step instructions	Explains 1 essential post-installation tasks (driver updates, Windows activation, security set-up, etc.) with step-by-step instructions	List 2 essential post-installation without explanation	List 1 essential post-installation without explanation
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SECTION 3: NETWORK SYSTEMS DESIGN AND IMPLEMENTATION

STRAND: COMPUTER ARCHITECTURE & ORGANISATION

Sub-strand: Data Communication and Network Systems

Content Standard: Demonstrate knowledge and understanding of the components of a network.

Learning Outcome: *Utilise knowledge of networking topologies to design and configure network systems to meet specific requirements.*

INTRODUCTION AND SECTION SUMMARY

This section focuses on data communication and network systems design, equipping students with practical knowledge to configure networks for specific requirements. Learners will analyse various network topologies, security measures, transmission media, and bandwidth considerations to design effective network solutions. Through hands-on activities and real-world scenarios, students will develop the technical skills to create network systems that balance performance, security, and scalability needs while addressing the practical challenges of implementation in various environments.

The section covers the following focal areas

Week 6: Network System Design and Implementation

Week 7: Internet Connectivity and Network Configuration

SUMMARY OF PEDAGOGICAL EXEMPLARS

In this section, hands-on demonstrations with physical network devices build foundational understanding while step-by-step router configuration activities develop practical skills. Through guided exploration of Ghana-specific connection methods and interactive IP addressing exercises, students gain contextual knowledge of networking principles. Collaborative scenario-based learning allows learners to apply concepts to real-world situations, with teacher facilitation ensuring proper implementation of network design principles and effective peer knowledge sharing through structured presentations.

ASSESSMENT SUMMARY

Depth of Knowledge (DOK) is employed in the assessment of learners to enhance the quality, validity and fairness of assessments while promoting deeper learning and critical thinking skills. Various forms of assessments are conducted to determine the learners' performance on the concepts that will be taught under this section. Teachers are entreated to administer these assessments and the record as hinted above for onward submission into the Student Assessment Portal (SAP).

Weeks	Indicator	DoK Level	Assessment Mode
6	Design and explain two network systems, considering factors such as topology, scalability and security (password, internet safety, malware awareness, data backups, securing personal devices and good security practices), transmission media and bandwidth.	1	Poster
7	Demonstrate how the system can connect to the Internet. 1. Demonstrate the configuration of network devices (e.g., hub, router, switch) to establish connectivity within a network. 2. Explain the steps involved in connecting a network system to the internet, including considerations for network addressing and security measures.	2	Questioning

WEEK 6

Learning Indicators

1. *Design and explain two network systems, considering factors such as topology, scalability and security (password, internet safety, malware awareness, data backups, securing personal devices and good security practices), transmission media and bandwidth*
2. *Discuss and compare the characteristics and advantages of at least three network topologies*

Recap weeks

Year 1	Week 7–8: Explain Computer Networks and how they work Week 9–1: Identify at least 3 Types of Network Systems
Year 2	Week 7–8: Design and explain 2 network systems. Week 9–11: Demonstrate how a network system can connect to the internet.

FOCAL AREA: NETWORK SYSTEM DESIGN AND IMPLEMENTATION

Network system design involves planning and implementing computer networks that meet specific organisational needs. This includes selecting appropriate network topologies, ensuring scalability for future growth, implementing security measures, choosing suitable transmission media and managing bandwidth effectively.

1. Network Topologies

From year 1 and 2, we learnt about the following network topologies,

- a. **Star Topology**, which has the following characteristics
 - i. All devices connect to a central device (hub, switch, or router)
 - ii. Each device requires its own cable to connect to the central device
 - iii. Most common topology in modern LANs
 - iv. Used in many Ghanaian schools and offices



Figure 3.1 Star Topology

Advantages

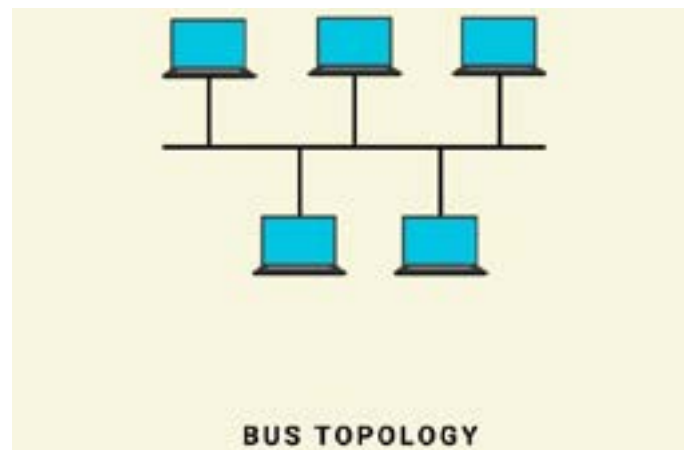
- i. Failure of one device or cable does not affect others
- ii. Easy to add, remove, or modify devices
- iii. Centralised management and monitoring
- iv. Better performance than bus topology
- v. Common in Ghanaian offices and educational institutions

Disadvantages

- i. Requires more cabling than bus topology
- ii. Dependent on central device (single point of failure)
- iii. Higher implementation cost

b. Bus Topology, which has the following characteristics

- i. All devices connect to a single central cable (backbone)
- ii. Simple to implement but less common in modern networks
- iii. May still be found in older installations in Ghana.

**Figure 3.2 Bus Topology****Advantages**

- i. Easy to set up and extend
- ii. Requires less cabling compared to other topologies
- iii. Well-suited for small networks
- iv. Cost-effective for linear arrangements (e.g., classrooms in Ghanaian schools)

Disadvantages

- i. If the main cable fails, the entire network fails
- ii. Performance degrades as more devices are added
- iii. Limited cable length restricts network size
- iv. Difficult to troubleshoot

c. Ring Topology, which has the following characteristics

- i. Devices are connected in a circular arrangement
- ii. Each device connects to exactly two other devices
- iii. Data travels in one direction around the ring

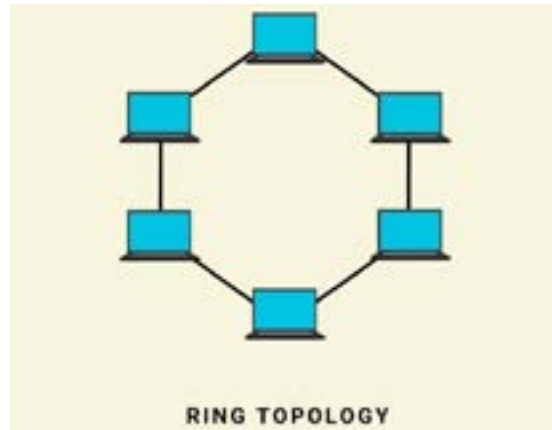


Figure 3.3 Ring Topology

Advantages

- i. Equal access for all devices
- ii. Performs well under heavy network load
- iii. No data collisions
- iv. Suitable for fibre optic networks

Disadvantages

- i. Failure of one device can affect the entire network
- ii. Adding or removing devices disrupts the network
- iii. More difficult to implement than bus or star topologies

d. Mesh Topology, which has the following characteristics

- i. Each device connects directly to multiple other devices
- ii. Provides redundancy and fault tolerance
- iii. Used in critical networks like banking systems in Ghana



Figure 3.4 Mesh Topology

Advantages

- i. High redundancy and fault tolerance
- ii. No single point of failure
- iii. Highly secure and private
- iv. Good for critical applications (e.g., banking networks in Ghana)

Disadvantages

- i. Very expensive to implement
- ii. Complex to set up and manage
- iii. Requires significant cabling
- iv. Difficult to scale

2. Scalability Considerations

Scalability in the context of computer networks refers to the ability of a network to grow and handle increasing demands without a significant drop in performance. Think of it like building a house; you might start with a small one, but you design it in a way that you can easily add more rooms in the future without having to tear down the whole structure. For a network, this means it can support more users, devices and traffic as an organisation or school grows.

a. Hardware Scalability

This is about the physical parts of the network and how they can be expanded.

- i. **Modular Equipment:** It is best to use network devices like switches and routers that are modular. This means they have slots where you can add more ports or functionalities.
- ii. **Planning for Future Capacity:** When setting up a new network, you should always plan for the future. If you only have 50 learners using the Wi-Fi now, consider that in two years, you might have 200. Therefore, you should install a wireless access point that can handle more users, even if it is not needed immediately.
- iii. **Hierarchical Design:** This is a smart way to organise a network into layers.
 - Access Layer: Where devices like computers and phones connect to the network.
 - Distribution Layer: Connects the access layers and provides policy-based connectivity.
 - Core Layer: The high-speed backbone of the network that connects all the distribution layers. This structure makes it easier to manage and expand the network. If one part of the school needs an upgrade, it does not affect the entire network.

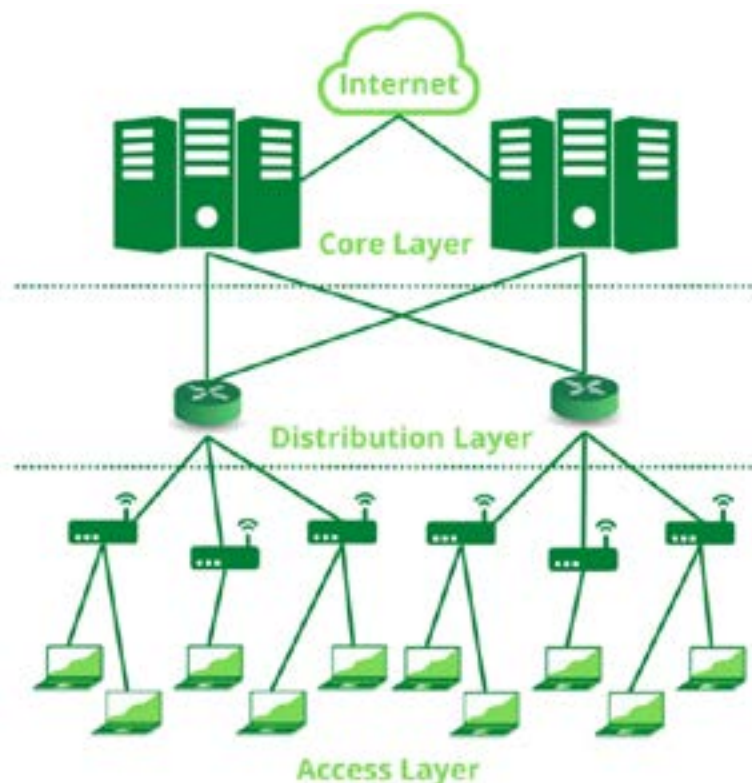


Figure 3.5 Hierarchical Design

b. Address Planning

Every device on a network needs a unique address, like a house number. This is its IP (Internet Protocol) address.

- i. **IP Addressing Schemes:** It is important to use an IP addressing plan that allows for growth. If you assign addresses randomly, you might run out quickly. A well-planned scheme ensures you have plenty of addresses available for new devices.
- ii. **Subnetting:** This is the process of dividing a large network into smaller, more manageable parts called subnets. Imagine a large school compound; instead of having one big address for the whole school, you can have separate address ranges for the classrooms, the library and the administrative offices.
- iii. **Planning for IPv6 Transition:** The world is running out of the current IP addresses (IPv4). The next generation is IPv6, which offers a virtually unlimited number of addresses. While IPv4 is still widely used both across the world and in Ghana, it is wise to use hardware and software that support IPv6 to be ready for the future.

c. Performance Scalability

As more people use the network, it can slow down. Performance scalability is about ensuring the network remains fast and responsive.

- i. **Handling Increased Traffic:** The network must be able to manage a higher volume of data. This means having switches and routers that can process data quickly.
- ii. **Bandwidth Upgrades:** Bandwidth is the amount of data that can be transferred over a network connection in a given time. Think of it as the width of a road; a wider road can handle more cars. As your school grows, you'll need to plan for

increasing your internet bandwidth from your service provider (e.g., Mobile broadband (MTN, Telecel, AT)).

- iii. **Quality of Service (QoS):** This is a way to prioritise network traffic. For example, in a school network, you would want to give video calls for online classes higher priority than someone downloading a large file. QoS ensures that critical applications get the bandwidth they need to run smoothly, even when the network is busy.

3. Security Measures

Network security is vital to protect data and resources from unauthorised access and cyber threats.

a. Password Security

- i. **Strong Password Policies:** Passwords are the first line of defence. A strong password should be long (at least 12 characters), and include a mix of uppercase and lowercase letters, numbers, and symbols (e.g., !, @, #). Avoid using easily guessable information like your name or date of birth.
- ii. **Regular Password Changes:** It is good practice to change your passwords every few months. This limits the damage if your password is ever stolen.
- iii. **Multi-Factor Authentication (MFA):** This adds an extra layer of security. Even if someone steals your password, they still cannot log in without a second piece of information, usually a code sent to your phone. Many services like Google and Facebook offer MFA.

b. Internet Safety

- i. **Safe Browse Practices:** Be cautious about the websites you visit. Avoid clicking on suspicious links or pop-up ads. Look for “https://” at the beginning of a website’s address, as the ‘s’ stands for secure.
- ii. **Recognising Phishing Attempts:** Phishing is when criminals try to trick you into giving them your personal information, like passwords or bank details, by sending fake emails or messages that look like they are from a legitimate company. Be wary of emails that create a sense of urgency or ask for your personal details.
- iii. **Secure Online Transactions:** When buying things online or using online banking, always make sure the website is secure. Look for the padlock symbol in the address bar. Avoid using public Wi-Fi for sensitive transactions.

c. Malware Protection

Malware (malicious software) includes viruses, worms, and ransomware that can harm your computer.

- i. **Antivirus and Anti-malware Software:** Install reputable antivirus software on your computer and keep it updated. This software can detect and remove malware.
- ii. **Regular System Updates:** Keep your operating system (like Windows or macOS) and your applications updated. These updates often include security patches that fix vulnerabilities that malware could exploit.

- iii. **User Education:** Knowing about malware threats is very important. Do not download files from untrusted sources or open email attachments from people you do not know.

d. Data Backup Strategies

Backing up your data means making a copy of your important files so that you can recover them if they are lost or damaged.

- i. **Regular Backup Schedules:** You should back up your data regularly, perhaps daily or weekly, depending on how often it changes. You can set up automatic backups, so you do not forget.
- ii. **On-site and Off-site Backup Solutions:** It is a good idea to have both.
- iii. **On-site:** Storing a backup on an external hard drive at your home or school.
- iv. **Off-site:** Storing a backup in a different physical location, for example, using a cloud storage service like Google Drive or OneDrive. This protects your data in case of a fire or theft at your primary location.
- v. **Testing Backup Restoration:** It is not enough to just back up your data; you need to make sure you can restore it. Occasionally, you should try to recover a file from your backup to ensure it is working correctly.

e. Device Security

- i. **Physical Security Measures:** Keep your devices like laptops and smartphones in a safe place. Use locks for computers in public labs.
- ii. **Device Encryption:** This scrambles the data on your device so that it is unreadable without the correct password. Modern smartphones are usually encrypted by default.
- iii. **Mobile Device Management (MDM):** In a school or company, MDM software can be used to manage and secure all the mobile devices that connect to the network. It can enforce security policies and even wipe the data from a lost or stolen device remotely.

4. Transmission Media

Transmission media is the physical path between the transmitter and the receiver in a data communication system. It is the “road” that data travels on.

a. Wired Media: This involves a physical cable.

- i. **Twisted Pair Cables (UTP, SAP):** These are the most common type of network cable, used for connecting computers in a Local Area Network (LAN).
 - **UTP (Unshielded Twisted Pair):** It is affordable and easy to install. You will find it used for telephone lines and computer networks.
 - **SAP (Shielded Twisted Pair):** It has an extra layer of shielding to protect against electrical interference, making it more suitable for noisy environments like factories.
- ii. **Coaxial Cables:** You might know this as the cable used for your DSTV or GOtv connection. It was also used for older computer networks. It has a single copper

conductor in the centre, surrounded by insulation and a braided metal shield commonly deployed as RG-6 or RG-59 coaxial cabling terminated with standard F-type connectors for satellite dishes, broadband cable television (CATV), and high-frequency RF transmission.

- iii. **Fibre Optic Cables:** These cables transmit data as pulses of light through thin strands of glass or plastic. They offer the highest speeds and bandwidth and are not affected by electrical interference. They are the backbone of the internet, connecting cities and countries through undersea cables.

b. Wireless Media: This transmits data through the air using electromagnetic waves.

- i. **Wi-Fi (802.11 standards):** This is the technology we use to connect to the internet wirelessly at home, school, or in public places like a mall. It uses radio waves to transmit data. The “802.11” refers to the set of standards that define how Wi-Fi works, with different versions (like 802.11n, 802.11ac, 802.11ax) offering different speeds and ranges.
- ii. **Bluetooth:** This is a short-range wireless technology used to connect devices like your phone to wireless headphones, speakers, and your computer. It is designed for communication over short distances, typically up to 10 metres.
- iii. **Cellular (3G, 4G, 5G):** This is the technology that our mobile phones use to connect to the internet through mobile networks like MTN, Telecel, and AT. The ‘G’ stands for generation.
 - 3G: Allowed for mobile internet access, but at slower speeds.
 - 4G (LTE): Offers much faster speeds, making it suitable for streaming videos and online gaming.
 - 5G: The latest generation, promising even faster speeds, lower latency (less delay) and the ability to connect a massive number of devices.

Learning Tasks

1. Learners participate in a brief discussion about the purpose of networks and what they remember about network design.
2. Learners watch the demonstration of network design and document the process.
3. Each group is assigned a scenario:
 - a. Scenario A: Design a network for a small primary school in rural Ghana
 - b. Scenario B: Design a network for a medium-sized business in Accra
4. Groups begin planning their network designs, considering:
 - a. Network topology
 - b. Required components
 - c. Basic security measures
 - d. Detailed security measures
 - e. Bandwidth allocation plans
 - f. Scalability considerations
5. Groups create simple network diagrams to illustrate their designs.

6. Each group presents their network design to the class.

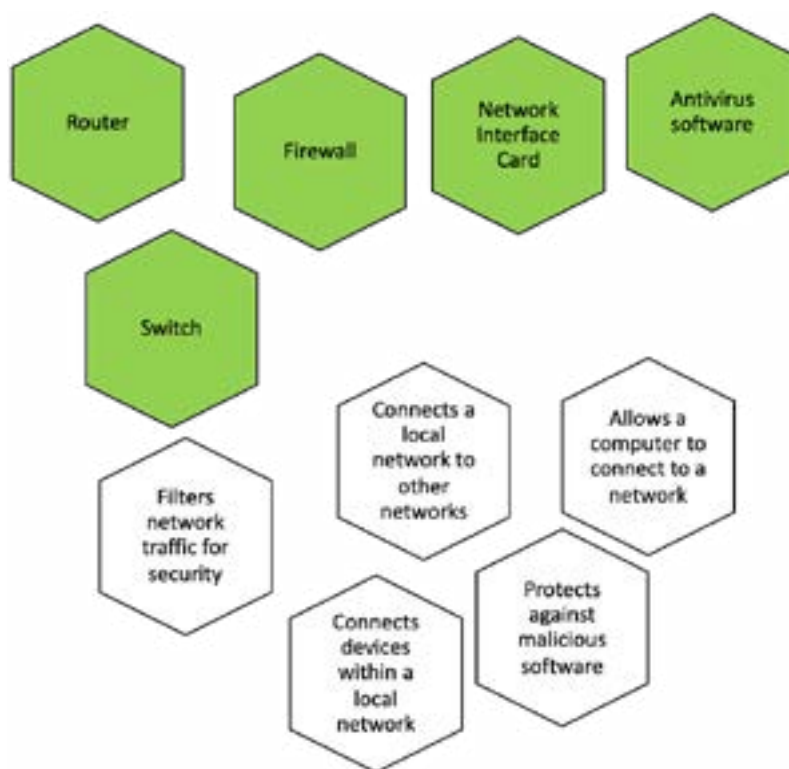
Pedagogical Exemplars

1. The teacher facilitates a discussion to review network concepts and topologies from Years 1 and 2 and emphasise their common application in Ghana.
2. The teacher demonstrates how to design a network or uses a video demonstration for learners to watch.
3. The teacher groups learners and assigns them a scenario.
4. The teacher moves around to provide guidance and answer questions on the scenario.
5. The teacher allocates time for each group to present their work.

Key Assessment: Mid-Semester Examination

DoK Level 1

- i. Match each network component (in green colours) with its correct function.
(1 mark each)



- ii. The arrangement of devices and connections in a network is called the network _____.
- iii. A _____ topology connects each device to every other device in the network.
- iv. A good security practice is to use _____ authentication, which requires more than just a password to access an account.

Hint

Conduct **Mid-semester Examination**. It should cover the contents taught from Week 1 to 5. Refer to the **Table of Specification and Structure of the Paper**. Learners' papers should be marked immediately and scores entered into the SAP.

Structure

Section A: 25 Multiple-choice questions

Section B: 2 Essay Questions

Table of specification for item construction for section A and B

Week	Learning Indicator	Types of questions	DoK Levels				Total
			1	2	3	4	
1	Determine and apply critical points of Logic Operations to solve a problem	MCQs	2	2	-		4
		ESSAY	-	-	-		-
2	Describe the arithmetic operations in the CPU, specifically Rotation and Shift Operations and explain their real-life applications	MCQs	2	2	2		6
		ESSAY	-	-	1		1
3	Discuss 3 major Arithmetic Operations and apply them taking into consideration their various functions	MCQs	-	2	1		3
		ESSAY	-	-	-		
4	Demonstrate the roles of Operating Systems and Utility Software as components of System Software	MCQs	3	2	1		6
		ESSAY					
5	Demonstrate the process of installing and managing an operating system	MCQs	1	3	2		6
		ESSAY			1		1
		Total	8	11	8		27

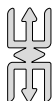
PLC Session 6

45 minutes

Planning & Reviewing the Learning Plan

1. Begin the session by recapping lessons from the previous session, focusing on how learning was applied.
2. Use your subject specific app to explore the content before planning. Ask the app to
 - a. explain the week's concepts in a practical way that will make it easier for learners to understand.
 - b. identify three common misconceptions learners may have on the week's content and how to address them using contexts familiar to Ghanaian learners (NTS 3a, 3g and 3m).
3. Use your subject specific app to plan your lesson. Ask the app to

- a. suggest the most effective method for teaching the week's concepts to learners with diverse backgrounds.
- b. suggest learning activities, differentiation and essential questions based on the method of teaching (NTS 3a-3q).
- c. review your prepared learning plan and address any challenging issues you may have identified in your subject area (NTS 3a-3c).



Note

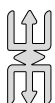
- Take note of the recap topics linked to Years 1 and 2 while preparing for your lesson.
- Refer to the Values Learning Community Handbook and link the values for the week in your lesson to ensure that learners are applying what they learn.

4. Use your app to plan and administer the mode of assessment for the Student Assessment Portal (SAP).
 - a. The key assessment for the week is **mid-semester examination**. Chat with your app to plan this assessment by reviewing or developing the assessment items/tasks and marking schemes/rubrics for the mid-semester examination (NTS 3k-3q).

10 minutes

Content Exploration

5. As a subject group, select one problem or topic/idea/term in the week's content that is challenging (not a routine procedural question, but one that requires conceptual understanding) and then
 - a. use the app, ask it to solve the problem step by step and explain the reasoning behind each step (you may be assisted by a teacher who is strong in the content area)
 - b. all teachers in the group work through the problem individually for 3–4 minutes
 - c. the group then works through the problem together, step by step
 - d. highlight the most common errors made at each step (NTS 1c, 1e, 2c, 2e, 3e-3j).



Note

- This part is not 'How do I teach this?' but how do I teach it for learners to understand?
- If the group still shares the same content gap, use the app: ask it to solve the problem step by step and explain the reasoning behind each step.
- Problems/ideas discussed should be sourced from the Teacher Manual content, not invented separately. This keeps the content exploration directly connected to what teachers will deliver.

30 minutes

Enactment

6. Enact a teaching activity based on your learning plan (NTS 1a-1b, 1e-1g, 2c, 2e, 2f, 3c-3j and 3o).
 - a. Colleagues observe with specific attention to clarity of concept explanation, use of familiar Ghanaian examples and how misconceptions are handled if they arise.

- b.** After the enactment, ask for structured feedback from the group
 - i. was the concept explained in a way that a learner with no prior knowledge could follow?
 - ii. were the examples grounded in contexts familiar to Ghanaian learners?
 - iii. did any misconceptions surface and if so, how were they addressed?

5 minutes	Reflection
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- 7.** Reflect and share your views on the session. One thing that worked well, what did not work well and what you will do differently. (NTS 1a, 1b).
- 8.** Identify a critical friend to observe and provide feedback on your lesson in relation to the PLC Session conducted (NTS 1f, 1g).
- 9.** Remember to
 - a.** transfer your chats into your learning planner template.
 - b.** read your Teacher Manual and related Learner Material in preparation for the next session. Take note of the recap weeks, which are linked to Years 1 and 2 (NTS 3a).
 - c.** integrate National Values, GESI, SEL, and 21st century skills into your learning activities, assessment tasks, and rubrics/mark schemes.

WEEK 7

Learning Indicators

1. Demonstrate how the system can connect to the Internet
2. Demonstrate the configuration of network devices (e.g., hub, router, switch) to establish connectivity within a network
3. Explain the steps involved in connecting a network system to the internet, including considerations for network addressing and security measures

Year 1	Week 7–8: Explain Computer Networks and how they work Week 9–10: Identify at least 3 Types of Network Systems
Year 2	Week 7–8: Design and explain 2 network systems. Week 9–11: Demonstrate how a network system can connect to the internet.

FOCAL AREA: INTERNET CONNECTIVITY AND NETWORK CONFIGURATION

Internet connectivity refers to the ability of a device or network to connect to the internet and access online resources. In Ghana and globally, internet connectivity has become essential for education, business, healthcare and daily communication. Understanding how to establish and maintain this connectivity is a crucial skill for computing learners.

Building on foundational routing concepts introduced in prior years, this week examines advanced network addressing schemes, subnetting architectures, and packet forwarding mechanisms.

1. Network Addressing

Think of a network like Ghana's postal system. For a letter to get to the right house, it needs a unique address. In the world of computer networks, this unique address is called an IP Address. It ensures that data sent over the internet or a local network reaches the correct destination.

a. IP Addressing

Every single device connected to a network—your phone, laptop, a smart TV, or even a printer—needs a unique IP (Internet Protocol) address to communicate. It's how devices find and talk to each other.

i. IPv4 vs. IPv6:

- IPv4 (Internet Protocol version 4) addresses are the most common type you'll see. They look like a set of four numbers separated by dots, for example, 192.168.1.1. There are about 4 billion possible IPv4 addresses, which seemed like a lot of years ago. However, with so many devices now connected to the internet, we are running out!
- IPv6 (Internet Protocol version 6) is the solution to this problem. IPv6 addresses are much longer and more complex (e.g., 2001:0db8:85a3:0000:0000:0000:0000:0000).

00:8a2e:0370:7334). They provide a massive, almost unlimited number of unique addresses for all the devices we will ever need. While IPv4 is still widely used, the world is slowly but surely moving to IPv6.

ii. **Assigning IP Addresses:** How does a device get its IP address? There are two ways:

- **Statically:** A network administrator can manually type in the IP address and other network details into a device's settings. This is like assigning a permanent, reserved parking spot. It is usually done for important, fixed devices like servers or printers, so they are always easy to find on the network.
- **Dynamically:** This is the most common method. An IP address is assigned automatically by a special server called a DHCP (Dynamic Host Configuration Protocol) server. When your phone connects to the school's Wi-Fi, it asks the DHCP server for an address. The server leases an available address to your phone for a certain period. This is like a car park attendant directing you to an empty space. It is efficient and prevents address conflicts.

b. DNS (Domain Name System)

Humans are good at remembering names, but computers work with numbers. While you can type an IP address directly into your browser, it is much easier to remember a name like www.moe.gov.gh.

DNS is the internet's phonebook. It translates the human-friendly domain names that we type into our web browsers into the computer-friendly IP addresses that are needed to locate the website's server.

When you type a web address, your computer asks a DNS server, "What is the IP address for www.moe.gov.gh?" The DNS server looks it up and sends the IP address back to your computer.

In Ghana, the DNS servers you use are often run by your Internet Service Provider (ISP), such as MTN or Vodafone. However, you can also use global DNS providers like Google (8.8.8.8) or Cloudflare (1.1.1.1), which can sometimes be faster and more reliable.

2. Network Security Measures

Network security involves protecting the network and the data on it from harm or unauthorised access. It is like having security guards, strong locks and secret codes to protect your school campus.

a. Firewalls

A firewall is a security guard for your network. It stands between your internal network (like your school's computer lab) and the outside internet, monitoring all the data traffic coming in and going out. It acts based on a set of security rules, blocking any suspicious or unauthorised traffic while letting safe communication pass through. Firewalls are essential for protecting school and business networks in Ghana from hackers and other online threats. They can be:

i. **Hardware Firewalls:** Physical devices that you plug in between your network and your internet connection.

- ii. **Software Firewalls:** Programs that run on your computer, like the Windows Defender Firewall.

b. Encryption

Encryption is the process of scrambling data so that it becomes unreadable to anyone who doesn't have the key to unscramble it. It is like writing a message in a secret code.

- i. **WPA2/WPA3 for Wi-Fi:** When you connect to a Wi-Fi network and have to enter a password, you are using encryption. WPA2 and the newer, more secure WPA3 are protocols that encrypt the data travelling between your device and the Wi-Fi router. This stops people nearby from “listening in” on your internet activity.
- ii. **SSL/TLS for Websites (HTTPS):** Have you ever noticed the padlock icon in your browser's address bar and that the address starts with “https://”? The ‘S’ stands for secure. This means your connection to the website is encrypted using SSL/TLS. This is vital for online banking, shopping, or entering any personal information online, as it protects your data from being stolen as it travels across the internet.
- iii. **VPN (Virtual Private Network):** A VPN creates a secure, encrypted “tunnel” for your internet traffic. It is useful for accessing a private network (like a school or office network) securely from a remote location. It also hides your IP address and encrypts your data, which is especially useful when using public Wi-Fi at places like a café or airport.

c. Authentication

Authentication is the process of proving you are who you say you are. It is how a system grants you access.

- i. **Username/Password Systems:** This is the most common form of authentication. You provide a username to identify yourself and a password that only you should know.
- ii. **Two-Factor Authentication (2FA):** This adds a second layer of security. After entering your password, you must provide a second piece of evidence. This is often a temporary code sent to your phone via SMS or an authenticator app – the app is significantly stronger than SMS and should be the preferred option where possible. So, even if a criminal steals your password, they can't log in without also having your phone. You should enable 2FA on important accounts like your email and social media.
- iii. **Biometric Authentication:** This method uses your unique physical characteristics to verify your identity. Common examples include:
 - Fingerprint scanners on phones and laptops.
 - Facial recognition (like Face ID on iPhones).
 - Iris scanners. Biometrics are very secure because they are difficult to copy or steal.

Learning Tasks

1. Learners identify and describe the function of each network device (hub, router, modem, etc) as a recap activity.
2. Learners observe and take notes on the configuration process
3. In groups, learners practice accessing router settings on available devices.
4. Learners follow along with teacher demonstrations on available devices and take notes.

Pedagogical Exemplars

1. The teacher introduces various network devices (hub, switch, router, etc) using physical examples or visual aids.
2. The teacher demonstrates how to access a router's configuration page (typically 192.168.0.1 or 192.168.1.1) using a web browser.
3. The teacher shows how to:
 - a. Set up a router password
 - b. Configure Wi-Fi settings (SSID, password, security type)
 - c. Set up DHCP for automatic IP assignment
4. The teacher explains different internet connection methods relevant to Ghana:
 - a. Mobile broadband (MTN, Vodafone, AirtelTigo)
 - b. Fixed broadband (fibre optic from providers like Surfline, Busy Internet)
 - c. DSL connections
5. Discussion of advantages and limitations of each method in the Ghanaian context.
6. The teacher explains IP addressing concepts and demonstrates how to:
 - a. Check a device's IP address
 - b. Configure static vs. dynamic IP addressing
 - c. Set up DNS servers

Key Assessment: Questioning

DoK Level 2

1. Which of the following represents the correct sequence of steps for configuring a router to connect a small office network to the internet? (1 mark)
 - A. Change default password → Connect router to modem → Configure Wi-Fi settings → Access router settings → Test connection
 - B. Set up Wi-Fi network → Connect router to modem → Change default password → Configure internet connection → Test connection
 - C. **Connect router to modem → Access router settings → Change default password → Configure internet connection → Set up Wi-Fi network → Test connection**

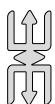
- D. Access router settings → Configure internet connection → Test connection → Change default password → Connect router to modem
2. Which statement correctly compares static and dynamic IP addressing in a Ghanaian context? (1 mark)
- A. **Static IPs are manually configured and remain constant, making them appropriate for Ghanaian businesses running servers.**
- B. Static IPs are automatically assigned by DHCP servers, making them ideal for Ghanaian home users with fluctuating internet connections.
- C. Dynamic IPs provide greater security than static IPs, making them the better choice for Ghanaian businesses hosting websites.
- D. Dynamic IPs are more expensive but provide faster connections than static IPs for Ghanaian educational institutions.
3. Identify and describe two potential security vulnerabilities in a typical network setup. (5 marks)

PLC Session 7

45 minutes

Planning & Reviewing the Learning Plan

1. Begin the session by recapping lessons from the previous year/session/week, focusing on how learning was applied.
2. Use your subject specific app to explore the content before planning. Ask the app to
 - a. explain the week's concepts in a practical way that will make it easier for learners to understand
 - b. identify two or three common misconceptions learners may have on the week's content and how to address them using contexts familiar to Ghanaian learners. (NTS 3a, 3g and 3m).
3. Use your subject specific app to plan your lesson. Ask the app to
 - a. suggest the most effective method for teaching the week's concepts to learners with diverse backgrounds.
 - b. suggest learning activities, differentiation and essential questions based on the method of teaching (NTS 3a-3q)
 - c. review your prepared learning plan and address any challenging issues you may have identified in your subject area (NTS 3a-3c).



Note

- Take note of the recap topics linked to Years 1 and 2 while preparing for your lesson.
- Refer to the Values Learning Community Handbook and link the values for the week in your lesson to ensure that learners are applying what they learn.

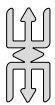
4. Plan the week's key assessment with your app

- a. The key assessment for the week is **questioning**. Chat with your app to plan this assessment, indicating what you and your learners will do before, during and after the questioning (NTS 3k-3q).

10 minutes

Content Exploration

5. As a subject group, select one problem or idea/term in the week's content that is challenging (not a routine procedural question, but one that requires conceptual understanding) and then
- use the app, ask it to solve the problem step by step and explain the reasoning behind each step (you may be assisted by a teacher who is strong in the content area)
 - all teachers in the group work through a similar problem individually for 3–4 minutes
 - the group then works through the problem together step by step
 - highlight the most common errors made at each step and discuss (NTS 1c, 1e, 2c, 2e, 3e-3j).

**Note**

- This part is not just about 'How do I teach this?' but how do I teach it for learners to understand?
- If the group still shares the same content gap, use the app: ask it to solve the problem step by step and explain the reasoning behind each step.
- Problems/ideas discussed should be sourced from the Teacher Manual content, not invented separately. This keeps the content exploration directly connected to what teachers will deliver.

30 minutes

Enactment

6. Enact a teaching activity based on your learning plan (NTS 1a-1b, 1e-1g, 2c, 2e, 2f, 3c-3j and 3o).
- Colleagues observe with specific attention to clarity of concept explanation, use of familiar Ghanaian examples and how misconceptions are handled if they arise.
 - After the enactment, ask for structured feedback from the group
 - was the concept explained in a way that a learner with no prior knowledge could follow?
 - were the examples grounded in contexts familiar to Ghanaian learners?
 - did any misconceptions surface and if so, how were they addressed?

5 minutes

Reflection

7. Reflect and share your views on the session. One thing that worked well, what did not work well and what you will do differently. (NTS 1a, 1b).
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- a. transfer your chats into your learning planner template.
- b. read your Teacher Manual and related Learner Material in preparation for the next session. Take note of the recap weeks, which are linked to Years 1 and 2 (NTS 3a).
- c. integrate National Values, GESI, SEL, and 21st century skills into your learning activities, assessment tasks, and rubrics/mark schemes.

Section Review

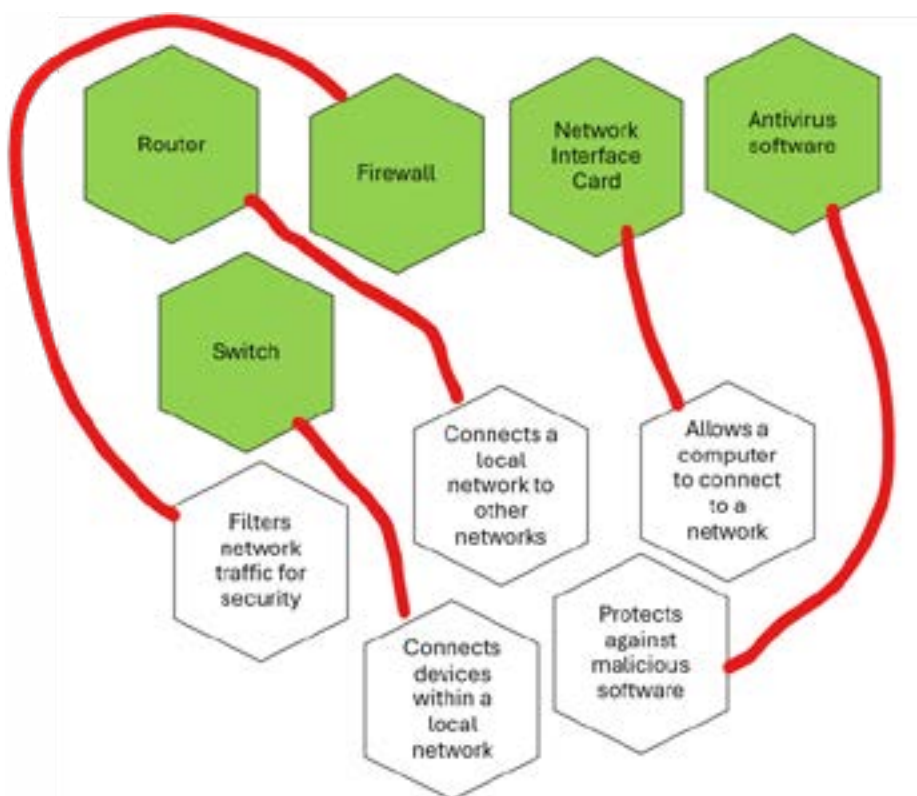
This section enhanced learners' networking capabilities through practical design and configuration activities. Learners mastered network topologies, security protocols and hardware configuration while developing critical skills in system installation and management. The hands-on approach enabled students to create functional network solutions that address real-world requirements for performance, security, and scalability.

MARKING SCHEMES FOR THE KEY ASSESSMENTS

WEEK 6

Expected Answers

1.



2. topology
3. mesh
4. multi-factor

WEEK 7

1. C
2. A
3. Rubric for question 3

Criteria	Very Good (3 marks)	Good (2 marks)	Need Improvement (1 mark)
Identification of potential security vulnerabilities	-	Identifies 2 potential security vulnerabilities in a typical network setup	Identify 1 potential security vulnerabilities in a typical network setup
Description of identified potential security vulnerabilities	Description of all identified potential security vulnerabilities in a typical network setup without spelling errors	Description of all identified potential security vulnerabilities in a typical network setup with spelling errors	Description of any identified potential security vulnerabilities in a typical network setup with or without spelling errors

SECTION 4: ARTIFICIAL INTELLIGENCE

STRAND: COMPUTATIONAL THINKING (PROGRAMMING LOGIC)

Sub-Strand: App Development

Content Standard: Demonstrate knowledge and understanding of Computational Thinking (Artificial Intelligence)

Learning Outcome: *Explain the concept of Artificial Intelligence and its applications and use the knowledge acquired to distinguish between conventional systems and intelligent systems.*

INTRODUCTION AND SECTION SUMMARY

This section explores the intersection of computational thinking, and artificial intelligence. Through comparative study of conventional and intelligent systems, learners will develop a foundational understanding of artificial intelligence concepts and applications. The section emphasises hands-on exploration, case studies and practical problem-solving to help learners recognise the emerging role of AI in data management and computational systems.

The section covered the following focal areas

Week 8: Artificial Intelligence (Principles, Components and Applications)

Week 9: Conventional Systems vs. Intelligent Systems (Analysis and Comparison)

SUMMARY OF PEDAGOGICAL EXEMPLARS

This section employs diverse teaching strategies including targeted questioning, physical demonstrations and mixed-ability collaborative research. Through hands-on exploration of storage devices, structured comparison activities and differentiated support, learners build understanding of mass storage technologies. The teacher facilitates active learning through guided research, strategic grouping based on GESI principles and whole-class discussions that clarify misconceptions. Differentiation strategies ensure all students engage meaningfully while extension activities challenge advanced learners to explore emerging storage technologies.

ASSESSMENT SUMMARY

Depth of Knowledge (DOK) is employed in the assessment of learners to enhance the quality, validity and fairness of assessments while promoting deeper learning and critical thinking skills. Various forms of assessments are conducted to determine the learners' performance on the concepts that will be taught under this section. Teachers are entreated to administer these assessments and the record as hinted above for onward submission into the Student Assessment Portal (SAP).

Weeks	Indicator	DoK Level	Assessment Mode
8	1. Describe the fundamental principles and components of Artificial Intelligence, such as machine learning, neural networks, and natural language processing 2. Discuss real-world applications of Artificial Intelligence, such as image recognition, language translation, and virtual assistants.	1	E-assessment
9	Analyse and compare the advantages and limitations of conventional systems and intelligent systems, considering factors such as problem-solving capabilities, adaptability, and learning capacity.	3	Debate

WEEK 8

Learning Indicators

1. Describe the fundamental principles and components of Artificial Intelligence, such as machine learning, neural networks, and natural language processing.
2. Discuss real-world applications of Artificial Intelligence, such as image recognition, language translation, and virtual assistants

Recap weeks

Year 2	Week 17: Use simulation tools in Machine Learning to train a computer to perform specific actions or sets of actions.
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FOCAL AREA: ARTIFICIAL INTELLIGENCE (PRINCIPLES, COMPONENTS AND APPLICATIONS)

Artificial Intelligence (AI) is a field of computer science focused on creating smart machines that can perform tasks that usually require human intelligence. Think about how you learn from experience, understand conversations and recognise faces. The goal of AI is to make computers do similar things as humans.

1. **Simulating Human Intelligence:** At its core, AI is about simulating our ability to think and learn in machines. These systems are not just following pre-written instructions; they are designed to analyse information, find patterns and make decisions.
2. **Learning and Adapting:** A key feature of AI is its ability to learn from experience. Just as you get better at a subject by studying past questions, an AI system can improve its performance by processing new data. For example, a navigation app like Google Maps learns about traffic jams and suggests faster routes by analysing real-time data from many users.
3. **Performing Complex Tasks:** The ultimate aim is to build systems that can handle tasks like translating languages, diagnosing diseases, or even driving a car. All of which were once thought to be possible only for humans.

Types of Artificial Intelligence

AI is often categorised into three types based on its capabilities.

1. **Narrow AI (Weak AI):** This is the only type of AI we have successfully built so far. Narrow AI is designed and trained to perform a specific task. It is very good at what it does, but it cannot operate outside its defined purpose.

Examples: The virtual assistant Siri on an iPhone can answer your questions and set alarms, but it cannot have a deep philosophical conversation. This represents the most basic form of AI available. More modern AIs have more capabilities such as ChatGPT, Gemini or Grok. The AI that recommends videos for you on YouTube is another example.



Figure 4.1 Siri icon

2. **General AI (Strong AI):** This is the next level of AI, which we have not achieved yet. General AI refers to a machine that has the same level of intelligence as a human. It would be able to understand, learn and apply its knowledge to solve any problem, just like a person can. This is the kind of AI you often see in science fiction movies.
3. **Super-intelligent AI:** This type of AI is purely theoretical. It refers to an intellect that is much smarter than the best human brains in practically every field, including scientific creativity, general wisdom and social skills. For now, this remains a concept for stories and future speculation.

Brief History of AI

The idea of intelligent machines has been around for a long time, but the modern field started taking shape in the mid-20th century.

1. **The Beginning:** The term “Artificial Intelligence” was first used in 1956 at a conference at Dartmouth College in the USA. Early AI research was very exciting and focused on creating rule-based systems that could solve problems and play games like chess.
2. **“AI Winters”:** The development of AI was not always a smooth ride. There were periods known as “AI winters” when progress slowed down, and funding and interest in the field decreased because the early promises were too difficult to achieve with the technology of the time.
3. **The Recent Boom:** In the last couple of decades, AI has experienced a massive resurgence. This is mainly due to three things:
 - a. **Increased Computing Power:** Modern computers are incredibly fast and powerful.
 - b. **Big Data:** We now have access to enormous amounts of data from the internet to train AI systems.
 - c. **Better Algorithms:** Scientists have developed more advanced methods and models for AI to learn effectively.

Components of Artificial Intelligence

AI is not just one single technology; it is made up of several key components that work together.

1. Machine Learning

Machine Learning (ML) is a subset of AI where computers have the ability to learn from data without being explicitly programmed. Instead of a developer writing step-by-step instructions for every possible situation, they create an algorithm that allows the computer to learn and improve on its own with experience.

- a. **Supervised Learning:** This is like studying with an answer key. The AI is trained on a dataset that is “labelled.” For example, to teach an AI to recognise spam emails, you would feed it thousands of emails that have already been labelled as either “spam” or “not spam.” The AI learns the patterns associated with each label.
- b. **Unsupervised Learning:** This is like being given a big pile of jumbled information and being asked to find groups or patterns on your own. The data is not labelled. This is useful for tasks like customer segmentation, where a business might want to group its customers based on their buying habits to create targeted advertisements.
- c. **Reinforcement Learning:** This is learning through trial and error. The AI learns by receiving rewards for correct actions and penalties for incorrect ones. Think of how a computer learns to play a video game. It gets a positive reward for scoring points and a negative one for losing a life. Over many tries, it figures out the best strategies to maximise its score.

2. Neural Networks

Neural Networks are computing systems inspired by the structure and function of the human brain. Our brains are made of billions of interconnected cells called neurons that pass signals to each other.

- a. **How They Work:** A neural network consists of interconnected nodes (artificial neurons) organised in layers. Data is fed into the first layer, which processes it and passes its output to the next layer and so on. Each connection has a weight that gets adjusted during the learning process.
- b. **Deep Learning:** When a neural network has many layers (sometimes hundreds), it is called Deep Learning. These “deep” networks are extremely powerful and can learn very complex patterns from huge amounts of data. Deep learning is the technology behind many recent AI breakthroughs.

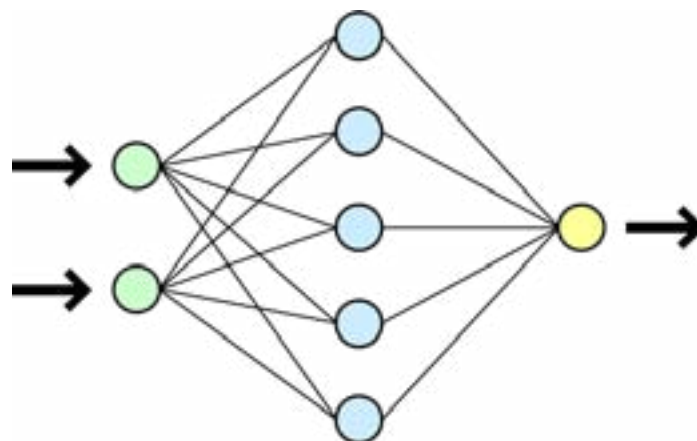


Figure 4.2 Illustration of Neural Networks

3. Natural Language Processing (NLP)

Natural Language Processing (NLP) is the branch of AI that gives computers the ability to understand, interpret, and generate human language, both text and speech.

Applications

- a. **Language Translation:** Services like Google Translate use NLP to translate text and speech from one language to another.

- b. **Chatbots and Virtual Assistants:** When you talk to a chatbot on a website or use Siri or Google Assistant, NLP is what allows it to understand your request and respond in a human-like way.
- c. **Speech Recognition:** This is how your phone converts your spoken words into text when you dictate a message.
- d. **Sentiment Analysis:** NLP can be used to analyse text (like social media comments) to determine if the writer's attitude is positive, negative, or neutral.

4. Computer Vision

Computer Vision is a field of AI that trains computers to “see” and interpret the visual world. Using digital images from cameras and videos, machines can identify and understand objects.

Applications

- a. **Image Recognition:** This is how social media platforms like Facebook can suggest tagging your friends in photos. The AI recognises their faces.
- b. **Object Detection:** Self-driving cars use computer vision to identify pedestrians, other cars, traffic signs, and lane markings to navigate safely.
- c. **Facial Recognition:** Used to unlock your smartphone or for security systems.
- d. **Medical Image Analysis:** Doctors can use computer vision to analyse medical scans like X-rays and MRIs to help detect diseases like cancer earlier and more accurately.

Real-World Applications of AI

1. **Image Recognition:** This is how computers “see.” AI helps your phone unlock using your face (Face ID) or helps Facebook suggest tagging your friends in photos because it recognises who is in the picture.
2. **Language Translation:** AI powers applications such as Google Translate and Apple's native Translate app. It helps you understand different languages. You can even point your phone's camera at a sign or a book, and it will translate the words for you. This is very useful in a country like Ghana with many languages.
3. **Virtual Assistants:** Such as Siri or Google Assistant, utilise NLP to execute tasks. You can use your voice to tell them to set an alarm for school, ask a quick question for your homework, or play your favourite music.
4. **Healthcare Applications:** AI helps doctors find diseases faster. For example, it can look at an X-ray or another medical scan and identify patterns or point out signs of a disease that might be hard for the human eye to see, helping doctors make a better diagnosis.
5. **Financial Services:** AI helps keep your money safe. When you use mobile money, AI systems watch for strange activity. If someone tries to use your account in a way that is not normal for you, AI can block the transaction to prevent fraud.
6. **Transportation:** AI helps you find the best way to get around. Apps like Google Maps use AI to check a number of factors such as road closures and traffic in real-time. It shows you the fastest route to take to avoid getting stuck in a traffic jam in places like Accra.

Learning Tasks

1. **Recap Discussion:** Learners participate in a brief, interactive discussion about their understanding of “smart” devices. They share examples of devices they have used that seem to “think” on their own, such as smartphones, smart TVs, or game consoles.
2. In groups, learners are assigned one real-world application of AI to explore using provided resources or internet access:
 - a. Group A: Image Recognition (e.g., Facebook photo tagging, phone Face ID).
 - b. Group B: Language Translation (e.g., Google Translate).
 - c. Group C: Virtual Assistants (e.g., Siri, Google Assistant).
 - d. Group D: AI in Finance (e.g., mobile money fraud detection).
 - e. Each group documents how the AI works in simple terms, list its benefits and find one challenge or limitation.
3. Each group presents its findings to the class.
4. If resources permit, learners interact with a virtual assistant on a phone or computer. They are to be given a list of tasks to complete, such as:
 - a. Ask the assistant to tell you about the weather in your city/town.
 - b. Ask it to translate ‘How are you?’ into French or any Ghanaian language.
 - c. Tell it to set a reminder for 5 minutes from now.
 - d. Learners will take notes on how the assistant responded and whether it completed the task successfully.

Pedagogical Exemplars

1. **Introduction with Visual Aids:** The teacher will introduce the concept of Artificial Intelligence using engaging visual aids, like short video clips showing AI in action (e.g., a self-driving car navigating, a robot performing a task).
2. **Guided Exploration:** As groups work on their assigned AI applications, the teacher moves to provide guidance, answer questions, and ensure learners are focusing on the core concepts. The teacher can prompt them with questions like, “What data do you think this AI needs to learn?” or “What could go wrong if this AI makes a mistake?”
3. **Interactive Demonstration:** The teacher will demonstrate how a specific AI works in a practical way. For example, using Google Translate on a projector to show real-time translation of text from English to a local Ghanaian language like Twi. The teacher will also show the camera translation feature to make the concept more tangible.
4. **Facilitated Discussion:** After the group presentations, the teacher leads a whole-class discussion. The teacher connects the different applications discussed back to the core components of AI (e.g., “The face tagging you found uses Computer Vision, and the virtual assistant uses Natural Language Processing.”).
5. The teacher relates the applications of AI to specific Ghanaian contexts. For example, discussing how AI-powered fraud detection is important for the security of mobile money services, which are widely used across the country.

Key Assessment: E-assessment

DoK Level 1

Scan this QR code or select [link](#) to take the quiz

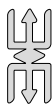


PLC Session 8

45 minutes

Planning & Reviewing the Learning Plan

1. Begin the session by recapping lessons from the previous year/session/week, focusing on how learning was applied.
2. Use your subject specific app to explore the content before planning. Ask the app to
 - a. explain the week's concepts in a practical way that will make it easier for learners to understand
 - b. identify two or three common misconceptions learners may have on the week's content and how to address them using contexts familiar to Ghanaian learners. (NTS 3a, 3g and 3m).
3. Use your subject specific app to plan your lesson. Ask the app to
 - a. suggest the most effective method for teaching the week's concepts to learners with diverse backgrounds.
 - b. suggest learning activities, differentiation and essential questions based on the method of teaching (NTS 3a-3q)
 - c. review your prepared learning plan and address any challenging issues you may have identified in your subject area (NTS 3a-3c).



Note

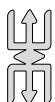
- Take note of the recap topics linked to Years 1 and 2 while preparing for your lesson.
- Refer to the Values Learning Community Handbook and link the values for the week in your lesson to ensure that learners are applying what they learn.

4. Plan the week's key assessment with your app
 - a. The key assessment for the week is **e-assessment**. Chat with your app to plan this assessment, indicating what you and your learners will do before, during and after the assessment (NTS 3k-3q).

10 minutes

Content Exploration

5. As a subject group, select one problem or idea/term in the week's content that is challenging (not a routine procedural question, but one that requires conceptual understanding) and then
 - a. use the app, ask it to solve the problem step by step and explain the reasoning behind each step (you may be assisted by a teacher who is strong in the content area)
 - b. all teachers in the group work through a similar problem individually for 3–4 minutes
 - c. the group then works through the problem together step by step
 - d. highlight the most common errors made at each step and discuss (NTS 1c, 1e, 2c, 2e, 3e-3j).



Note

- This part is not just about 'How do I teach this?' but how do I teach it for learners to understand?
- If the group still shares the same content gap, use the app: ask it to solve the problem step by step and explain the reasoning behind each step.
- Problems/ideas discussed should be sourced from the Teacher Manual content, not invented separately. This keeps the content exploration directly connected to what teachers will deliver.

30 minutes

Enactment

6. Enact a teaching activity based on your learning plan (NTS 1a-1b, 1e-1g, 2c, 2e, 2f, 3c-3j and 3o).
 - a. Colleagues observe with specific attention to clarity of concept explanation, use of familiar Ghanaian examples and how misconceptions are handled if they arise.
 - b. After the enactment, ask for structured feedback from the group
 - i. was the concept explained in a way that a learner with no prior knowledge could follow?
 - ii. were the examples grounded in contexts familiar to Ghanaian learners?
 - iii. did any misconceptions surface and if so, how were they addressed?

5 minutes

Reflection

7. Reflect and share your views on the session. One thing that worked well, what did not work well and what you will do differently. (NTS 1a, 1b).
8. Identify a critical friend to observe and provide feedback on your lesson in relation to the PLC Session conducted (NTS 1f, 1g).
9. Remember to
 - a. transfer your chats into your learning planner template.
 - b. read your Teacher Manual and related Learner Material in preparation for the next session. Take note of the recap weeks, which are linked to Years 1 and 2 (NTS 3a).
 - c. integrate National Values, GESI, SEL, and 21st century skills into your learning activities, assessment tasks, and rubrics/mark schemes.

WEEK 9

Learning Indicator: *Analyse and compare the advantages and limitations of conventional systems and intelligent systems, considering factors such as problem-solving capabilities, adaptability, and learning capacity*

Recap weeks

Year 2	Use simulation tools in Machine Learning to train a computer to perform specific actions
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FOCAL AREA: CONVENTIONAL SYSTEMS VS. INTELLIGENT SYSTEMS (ANALYSIS AND COMPARISON)

1. Conventional Computing Systems

Conventional computing systems are deterministic architectures governed by static procedural algorithms, executing explicit, hard-coded instructions without the capacity to autonomously infer rules or adapt to unprogrammed variables. Think of them like robots that need very specific instructions for everything.

- a. They work by following step-by-step instructions (called algorithms)
- b. They cannot figure things out on their own
- c. They always give the same answer when given the same input
- d. They cannot learn from their mistakes or get better over time

Examples of these computing systems are

- e. ATM machines at banks
- f. The systems your school uses to store your grades
- g. Government computers that keep track of citizens
- h. Basic apps on your phone
- i. Regular websites

2. Intelligent Systems

Intelligent systems are like the “smart” version of computers. They can understand what is happening around them, learn from their experiences and change how they behave without someone having to reprogram them.

- a. They can figure things out even with incomplete information
- b. They get better at tasks over time as they gain experience
- c. They can think in ways that are similar to humans
- d. They can make educated guesses when they not 100% sure.

3. Examples are

- a. Systems that help farmers detect plant diseases before they spread

- b. Programs that spot suspicious transactions in Mobile Money services
- c. Tools that help doctors diagnose medical conditions
- d. Apps that translate between English and local languages like Twi or Ewe
- e. Systems that help manage traffic flow in busy cities like Ho and Kumasi

4. Comparing Conventional vs. Intelligent Systems

Conventional computing systems are like reliable workers who follow exact instructions. They excel at well-defined tasks with clear rules but cannot adapt without human help. They are predictable, transparent and run on basic hardware, making them affordable and easy to understand. In contrast, intelligent systems are like smart apprentices who learn from experience. They can tackle complex problems, discover patterns in messy data and improve over time without reprogramming. While they are more flexible and creative, they require powerful computers, specialised expertise and often work as “black boxes” that cannot explain their decisions. Think of the difference as a calculator versus a human tutor – the calculator always gives the same answer to $2+2$, while the tutor adapts teaching methods based on your needs and improves with experience.

5. Hybrid Approaches

Hybrid systems cleverly combine traditional computing with intelligent systems to get the best of both worlds. These practical systems use rule-based foundations for reliability while adding learning capabilities for flexibility. They strike a balance between the explainability of conventional systems and the adaptability of intelligent ones. In Ghana, we see these hybrid approaches in smart farming tools that blend traditional agricultural knowledge with AI-powered disease detection. They are also used in healthcare, where standard medical protocols work alongside AI diagnostic assistants to improve patient care. Educational platforms represent another example, offering structured lessons while adapting to each learner’s learning pace and style.

Learning Tasks

1. In groups, learners create a comparison chart between conventional computing systems and intelligent systems. Each group should identify at least 3 key differences in terms of:
 - a. Problem-solving capabilities
 - b. Adaptability
 - c. Learning capacity
 - d. Resource requirements
 - e. Transparency and explainability
2. Learners identify and document at least two real-world examples of each system type currently used in Ghana.
3. Learners debate on the topic: “Intelligent systems will eventually replace conventional computing systems in Ghana.”. Refer to Key Assessment question 1 for the debate structure.

Pedagogical Exemplars

1. **Direct Instruction with Multimedia:** The teacher presents the concepts of conventional computing systems, intelligent systems and hybrid approaches using clear visual aids, diagrams, and real-world examples relevant to the Ghanaian context. The presentation should include:
 - a. Definitions and characteristics of each system type
 - b. Key components with visual representations
 - c. Comparative analysis using simple tables or charts
2. **Collaborative Learning:** The teacher organises learners into groups to complete Task 1 (Comparison Chart) and Task 2 (Real-World Examples).
3. **Discussion-Based Learning:** The teacher facilitates a whole-class discussion after Task 3 (Debate Activity):
 - a. Guides learners to reflect on different perspectives presented
 - b. Uses questioning techniques to deepen understanding
 - c. Connects debate points to real-world applications in Ghana
 - d. Addresses misconceptions about both system types

Note: Teacher is to ensure rubric is shown to learners before the debate commences.

Key Assessment: Debate

DoK Level 3

1. **Task:** Analyse and evaluate the statement “Intelligent systems will eventually replace conventional computing systems in Ghana.” Present arguments for and against this statement, considering the unique context of Ghana’s technological infrastructure, economic factors, and social needs. In your response:
 - a. Compare and contrast the capabilities of conventional and intelligent systems
 - b. Evaluate the strengths and limitations of each system type in the Ghanaian context
 - c. Analyse how hybrid approaches might provide alternative solutions with examples.
 - d. Support your arguments with specific examples and evidence
 - e. Draw a reasoned conclusion based on your analysis

DoK level 4

2. **Scenario:** You are the ICT Director for a group of 20 Senior High Schools across Ghana (10 urban, 10 rural). The Ghana Education Service has given you a budget of GHS 2 million to upgrade all school computer systems over the next 3 years. You must choose between conventional systems or intelligent systems for different schools.

Your Task: Design a comprehensive technology implementation strategy that addresses the diverse needs of these schools. In your strategy:

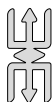
- a. Analyse how problem-solving capabilities, adaptability and learning capacity of both system types will impact student learning in urban vs rural contexts
- b. Compare the advantages and limitations of each system type for different educational activities (research, programming, administrative tasks, learners assessments)
- c. Justify your allocation decisions by evaluating which schools should receive which systems based on infrastructure, student needs and long-term educational goals
- d. Create a 3-year implementation timeline that considers budget constraints, teacher training requirements and maintenance capabilities.
- e. Develop contingency plans for potential challenges (power outages, internet connectivity issues, system failures)

PLC Session 9

45 minutes

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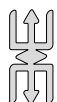
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- c. integrate National Values, GESI, SEL, and 21st century skills into your learning activities, assessment tasks, and rubrics/mark schemes.

Section Review

This section enhanced learners' understanding of artificial intelligence through hands-on exploration and critical analysis. By examining conventional versus intelligent systems, learners developed practical skills in designing optimised solutions. The contextual approach featuring Ghanaian scenarios ensured students could apply their knowledge to relevant local challenges while understanding emerging AI applications.

MARKING SCHEME FOR THE KEY ASSESSMENTS

WEEK 9

Question 1

Criteria	Excellent (4)	Good (3)	Satisfactory (2)	Need Improvement (1)
Comparative Analysis	Provides a comparison with 4 distinct points	Provides a comparison with 3 distinct points	Provides a comparison with 2 distinct points	Provide a comparison with 1 distinct point
Contextual Relevance	Analyses how each system type relates to Ghana with 3 contextual factors considered.	Analyses how each system type relates to Ghana with 2 contextual factors considered.	Analyses how each system type relates to Ghana with 1 contextual factor considered.	System analysis does not relate to Ghana.
Evidence and Examples	Supports arguments with 3 relevant examples and evidence.	Supports arguments with 2 relevant examples and evidence.	Supports arguments with 1 relevant examples and evidence.	Example is not relevant to argument.
Conclusion Remark	-	Conclusion highlights at least 3 points mentioned	Conclusion highlights at least 2 points mentioned	Conclusion highlights at least 1 point mentioned

SECTION 5: WEB TECHNOLOGIES AND DATABASES

STRAND: COMPUTATIONAL THINKING (PROGRAMMING LOGIC)

Sub-Strand: Web Technologies

Content Standard: Demonstrate knowledge and understanding of Web development

Learning Outcome: *Use skills and knowledge acquired to design simple web pages*

SECTION SUMMARY AND INTRODUCTION

Section 5 explores creating e-commerce websites with database integration. It explains the techniques and process of how teachers can guide learners to build attractive product displays using HTML and CSS, then advance to connecting websites with databases through PHP. This connection transforms static sites into scalable e-commerce platforms that dynamically retrieve and display product information. By the end of the section end, learners will have the skill to create a functioning e-commerce website pulling data from a database.

The focal areas for the section are

Week 10: Creating a Database

Week 11: Creating a Simple E-commerce Website

Week 12: Connecting a Website to a Database

Week 13

1. Password Security and Authentication
2. Understanding Cybersecurity Threats

Week 14

1. Smartphone Security Practices
2. Personal Data Protection

PEDAGOGICAL SUMMARY

This section employs scaffolded learning through guided discovery and other pedagogy to teach e-commerce database integration. Mixed-ability grouping supports collaborative problem-solving while flipped classroom techniques and real-world scenarios enhance engagement. Practical implementation is balanced with reflection to develop both technical skills and conceptual understanding.

ASSESSMENT SUMMARY

Depth of Knowledge (DOK) is employed in the assessment of learners to enhance the quality, validity and fairness of assessments while promoting deeper learning and critical thinking skills. Various forms of assessments are conducted to determine the learners' performance on the concepts that will be taught under this section. Teachers are entreated to administer these assessments and the record as hinted above for onward submission into the Student Assessment Portal (SAP).

Weeks	Indicator	DoK Level	Assessment Mode
10	1. Utilise web page editors and design principles to create visually appealing and user-friendly web pages, incorporating sections, text, images, and Graphical User Interface (GUI) elements. 2. Design an e-commerce web page for a selected company or organisation	4	Essay
11		2	Essay
12		2	Practice Paper 1 Discussion
13	<i>Understand and Apply Basic Cyber Security Best Practice</i>	3	Case Study
14	<i>Understand and Apply Basic Cyber Security Best Practice</i>	3	Case study

WEEK 10

Learning Indicators

1. *Utilise web page editors and design principles to create visually appealing and user-friendly web pages, incorporating sections, text, images, and Graphical User Interface (GUI) elements*
2. *Design an e-commerce web page for a selected company or organisation*

Recap Weeks

Year 1	Week 22: Identify and describe the key components of a Web page, including headings, menus, links, text, images, and other relevant elements.
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FOCAL AREA: CREATING A DATABASE

A database is an organised collection of data that can be easily accessed, managed, and updated. For an e-commerce site, a database stores product information like names, prices, and images.

Tools Required

- a. Use **XAMPP** (to simulate a web server and use MySQL database)
- b. OR **SQLite** (a lightweight database that stores data in a file)
- c. Basic SQL knowledge

Steps to Create a MySQL Database Using XAMPP

- a. Open XAMPP, start Apache and MySQL.
- b. Open your browser and go to: <http://localhost/phpmyadmin>
- c. Click “New” to create a new database. Name it `ecommerce_db`.
- d. Click on the new database and select “Create table”. Name it `products` and give it 4 columns:
 - `id` – INT – Primary key – Auto increment
 - `productName` – VARCHAR(100)
 - `price` – DECIMAL(6,2)
 - `image_url` – VARCHAR(255)
- e. Click Save and insert 2 to 3 product entries.

Learning Tasks

1. Recap activities
 - a. Create a concept map showing the relationship between databases and e-commerce websites.
 - b. Write a short paragraph explaining why relational databases are important for e-commerce websites, focusing on data management, integrity and real-time operations.

- c. In your own words, explain what a table, column, row and primary key are in a database.
 2. Working with a partner, design the following database tables for an e-commerce website on paper:
 - a. Products table (with columns: id, productName, price, description, image_url, stock_quantity)
 - b. Customers table (with columns: id, firstName, lastName, email, phone, address)
 - c. Orders table (with columns: id, customer_id, order_date, total_amount, status)
 - d. Identify the primary keys for each table.
 - e. Draw arrows showing how these three tables are related to each other.
 - f. Explain to your partner how these tables would work together when a customer places an order.
 3. Creating a Simple Database (Practical Activity)
 - a. Open XAMPP and start Apache and MySQL services.
 - b. Navigate to phpMyAdmin in your browser (<http://localhost/phpmyadmin>).
 - c. Create a new database named “ecommerce_db”.
 - d. Create the “products” table with the following columns:
 - i. id (INT, Primary key, Auto increment)
 - ii. productName (VARCHAR(100))
 - iii. price (DECIMAL(10,2))
 - iv. image_url (VARCHAR(255))
 - e. Insert at least 3 product entries with real product names, prices, and image URLs.
 - f. Show your table to the teacher.
 4. Extended Activity (for learners who are able to complete task 1-3 quickly)
 - a. Create two additional tables in your database:
 - i. “categories” (id, category_name)
 - ii. “product_categories” (product_id, category_id)
 - b. Insert at least 3 categories.
 - c. Assign your products to appropriate categories.
 - d. Write a query that shows all products with their category names.
 - e. Discuss with your peers or teacher how this relationship improves the e-commerce database structure.

Pedagogical Exemplars

1. **Flipped Classroom:** Provide preparatory materials (video tutorials and reading materials) on basic database concepts and XAMPP setup for students to study at home. Use class time for hands-on practice creating databases and answering questions under the teacher's guidance.
2. **Direct Instruction with Multimedia:** Use slideshow presentations with visual aids to introduce database concepts. Include screenshots of phpMyAdmin, database tables and relationships. Demonstrate live how to create a database, tables, and insert data using XAMPP and phpMyAdmin.
3. **Visualisation and Real-life Examples:** Use multimedia tools and real-world e-commerce websites to help students visualise how databases work behind the scenes. Show examples of popular e-commerce platforms such as Jumia or Hubtel and explain how their databases might be structured to handle products, customers, and orders.
4. **Hands-on Practical – Group Work:** Put learners into mixed-ability groups. Each group will design and create a database for a specific type of e-commerce store (e.g., clothing, electronics, groceries).
5. **Collaborative Learning:** Organise learners to work together in small groups to complete database creation tasks.

Key Assessment: Group Work

DoK Level 1

1. Which of the following is NOT a component of a relational database?
 - A. Columns
 - B. Hyperlinks**
 - C. Rows
 - D. Tables
2. In an e-commerce database, why would the product table and the order table need to be related?
 - A. To reduce the database size
 - B. To track which products were included in which orders**
 - C. To make the database load faster
 - D. To prevent customers from ordering products

DoK Level 2

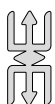
3. List and briefly describe the four main components of a relational database.

PLC Session 10

45 minutes

Planning & Reviewing the Learning Plan

1. Begin the session by recapping lessons from the previous year/session/week, focusing on how learning was applied.
2. Use your subject specific app to explore the content before planning. Ask the app to
 - a. explain the week's concepts in a practical way that will make it easier for learners to understand
 - b. identify two or three common misconceptions learners may have on the week's content and how to address them using contexts familiar to Ghanaian learners. (NTS 3a, 3g and 3m).
3. Use your subject specific app to plan your lesson. Ask the app to
 - a. suggest the most effective method for teaching the week's concepts to learners with diverse backgrounds.
 - b. suggest learning activities, differentiation and essential questions based on the method of teaching (NTS 3a-3q)
 - c. review your prepared learning plan and address any challenging issues you may have identified in your subject area (NTS 3a-3c).



Note

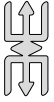
- Take note of the recap topics linked to Years 1 and 2 while preparing for your lesson.
- Refer to the Values Learning Community Handbook and link the values for the week in your lesson to ensure that learners are applying what they learn.

4. Plan the week's key assessment with your app
 - a. The key assessment for the week is **group work**. Chat with your app to plan this assessment, indicating what you and your learners will do before, during and after the group work (NTS 3k-3q).

10 minutes

Content Exploration

5. As a subject group, select one problem or idea/term in the week's content that is challenging (not a routine procedural question, but one that requires conceptual understanding) and then
 - a. use the app, ask it to solve the problem step by step and explain the reasoning behind each step (you may be assisted by a teacher who is strong in the content area)
 - b. all teachers in the group work through a similar problem individually for 3–4 minutes
 - c. the group then works through the problem together step by step
 - d. highlight the most common errors made at each step and discuss (NTS 1c, 1e, 2c, 2e, 3e-3j).



Note

- This part is not just about ‘How do I teach this?’ but how do I teach it for learners to understand?
- If the group still shares the same content gap, use the app: ask it to solve the problem step by step and explain the reasoning behind each step.
- Problems/ideas discussed should be sourced from the Teacher Manual content, not invented separately. This keeps the content exploration directly connected to what teachers will deliver.

30 minutes

Enactment

6. Enact a teaching activity based on your learning plan (NTS 1a-1b, 1e-1g, 2c, 2e, 2f, 3c-3j and 3o).
 - a. Colleagues observe with specific attention to clarity of concept explanation, use of familiar Ghanaian examples and how misconceptions are handled if they arise.
 - b. After the enactment, ask for structured feedback from the group
 - i. was the concept explained in a way that a learner with no prior knowledge could follow?
 - ii. were the examples grounded in contexts familiar to Ghanaian learners?
 - iii. did any misconceptions surface and if so, how were they addressed?

5 minutes

Reflection

7. Reflect and share your views on the session. One thing that worked well, what did not work well and what you will do differently. (NTS 1a, 1b).
8. Identify a critical friend to observe and provide feedback on your lesson in relation to the PLC Session conducted (NTS 1f, 1g).
9. Remember to
 - a. transfer your chats into your learning planner template.
 - b. read your Teacher Manual and related Learner Material in preparation for the next session. Take note of the recap weeks, which are linked to Years 1 and 2 (NTS 3a).
 - c. integrate National Values, GESI, SEL, and 21st century skills into your learning activities, assessment tasks, and rubrics/mark schemes.

WEEK 11

Learning Indicators

1. Utilise web page editors and design principles to create visually appealing and user-friendly web pages, incorporating sections, text, images, and Graphical User Interface (GUI) elements
2. Design an e-commerce web page for a selected company or organisation

FOCAL AREA: CREATE A SIMPLE E-COMMERCE WEBSITE

An e-commerce web-page allows users to view or buy products/services online.

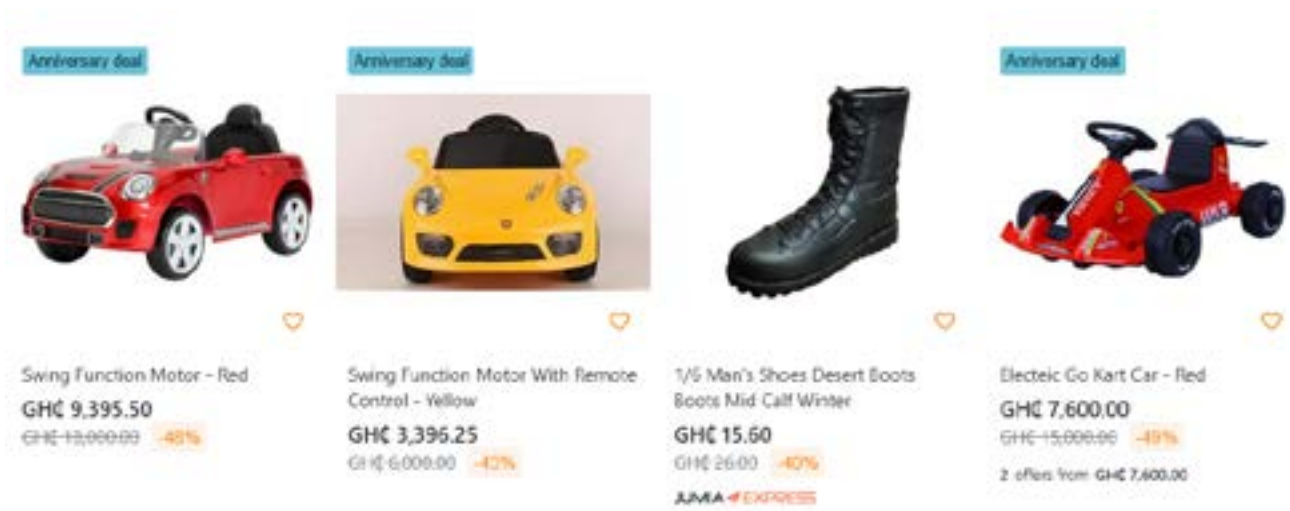


Figure 5.1 Sample of Ecommerce Page

Tools Required

1. A code editor like **Visual Studio Code (VS Code)**
2. Basic knowledge of **HTML** and **CSS**

Create a container (#products) where product data will appear using sample code

Sample Code

```
<!DOCTYPE html>
<html>
  <head>
    <title>My Shop</title>
    <style>
      body { font-family: Arial; }
      .product { border: 1px solid #ccc; padding: 10px; margin: 10px; }
      img { width: 100px; height: auto; }
    </style>
  </head>

  <body>
    <h1>Welcome to My Online Shop</h1>
```

```

<div id="products">
<!-- Products will be displayed here -->
</div>
</body>
</html>

```

Learning Tasks

1. Learners study preparatory materials on e-commerce websites before class, focusing on basic structure and elements of online shops (by using bootstrap, w3 schools or any other coding learning platform).
2. Learners listen to and interact with the teacher's explanation of e-commerce website components, take notes, and ask questions to clarify their understanding of product displays and HTML/CSS structure.
3. In mixed-ability groups, learners identify features for an e-commerce site for a chosen local company or fictional brand, then apply the sample code provided to develop a basic product display page.

Pedagogical Exemplars

1. **Flipped Classroom:** Provide learners with the sample code and basic e-commerce concepts to review at home (explore w3 schools or bootstrap template). Use class time for hands-on development of their e-commerce websites with teacher guidance.
2. **Interactive Demonstration:** Demonstrate how to modify the sample code to display different products, explaining HTML structure and CSS styling elements. Allow students to suggest modifications in real-time.
3. **Collaborative Learning:** Form groups where learners with stronger coding skills can support those who need more assistance. Each group selects a local business or creates a fictional brand to develop an e-commerce site for.
4. **Scaffolded Learning:** Provide templates at different complexity levels to accommodate various skill levels. Basic templates include more complete code, while advanced templates require more independent coding.

Key Assessment: Essay

DoK Level 2

1. What would be the effect of changing width: 100px; to width: 200px; in the image styling?
 - A. The images would become taller
 - B. The images would become wider
 - C. The images would disappear
 - D. There would be no change to the images
2. If you wanted to add a "Buy Now" button to each product, which HTML element would be most appropriate?
 - A. <p>

- B.
- C. <button>
- D. <div>

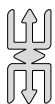
3. Describe how you would modify the sample code to add prices and “Add to Cart” buttons for each product.

PLC Session 11

45 minutes

Planning & Reviewing the Learning Plan

1. Begin the session by recapping lessons from the previous year/session/week, focusing on how learning was applied.
2. Use your subject specific app to explore the content before planning. Ask the app to
 - a. explain the week’s concepts in a practical way that will make it easier for learners to understand
 - b. identify two or three common misconceptions learners may have on the week’s content and how to address them using contexts familiar to Ghanaian learners. (NTS 3a, 3g and 3m).
3. Use your subject specific app to plan your lesson. Ask the app to
 - a. suggest the most effective method for teaching the week’s concepts to learners with diverse backgrounds.
 - b. suggest learning activities, differentiation and essential questions based on the method of teaching (NTS 3a-3q)
 - c. review your prepared learning plan and address any challenging issues you may have identified in your subject area (NTS 3a-3c).



Note

- Take note of the recap topics linked to Years 1 and 2 while preparing for your lesson.
- Refer to the Values Learning Community Handbook and link the values for the week in your lesson to ensure that learners are applying what they learn.

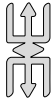
4. Plan the week’s key assessment with your app
 - a. The key assessment for the week is **essay**. Chat with your app to plan this assessment, indicating what you and your learners will do before, during and after the essay (NTS 3k-3q).

10 minutes

Content Exploration

5. As a subject group, select one problem or idea/term in the week’s content that is challenging (not a routine procedural question, but one that requires conceptual understanding) and then
 - a. use the app, ask it to solve the problem step by step and explain the reasoning behind each step (you may be assisted by a teacher who is strong in the content area)

- b. all teachers in the group work through a similar problem individually for 3–4 minutes
- c. the group then works through the problem together step by step
- d. highlight the most common errors made at each step and discuss (NTS 1c, 1e, 2c, 2e, 3e-3j).



Note

- This part is not just about ‘How do I teach this?’ but how do I teach it for learners to understand?
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- Problems/ideas discussed should be sourced from the Teacher Manual content, not invented separately. This keeps the content exploration directly connected to what teachers will deliver.

30 minutes

Enactment

6. Enact a teaching activity based on your learning plan (NTS 1a-1b, 1e-1g, 2c, 2e, 2f, 3c-3j and 3o).
 - a. Colleagues observe with specific attention to clarity of concept explanation, use of familiar Ghanaian examples and how misconceptions are handled if they arise.
 - b. After the enactment, ask for structured feedback from the group
 - i. was the concept explained in a way that a learner with no prior knowledge could follow?
 - ii. were the examples grounded in contexts familiar to Ghanaian learners?
 - iii. did any misconceptions surface and if so, how were they addressed?

5 minutes

Reflection

7. Reflect and share your views on the session. One thing that worked well, what did not work well and what you will do differently. (NTS 1a, 1b).
8. Identify a critical friend to observe and provide feedback on your lesson in relation to the PLC Session conducted (NTS 1f, 1g).
9. Remember to
 - a. transfer your chats into your learning planner template.
 - b. read your Teacher Manual and related Learner Material in preparation for the next session. Take note of the recap weeks, which are linked to Years 1 and 2 (NTS 3a).
 - c. integrate National Values, GESI, SEL, and 21st century skills into your learning activities, assessment tasks, and rubrics/mark schemes.

WEEK 12

Learning Indicators

1. *Utilise web page editors and design principles to create visually appealing and user-friendly web pages, incorporating sections, text, images, and Graphical User Interface (GUI) elements*
2. *Design an e-commerce web page for a selected company or organisation*

FOCAL AREA: CONNECTING A WEBSITE TO THE DATABASE

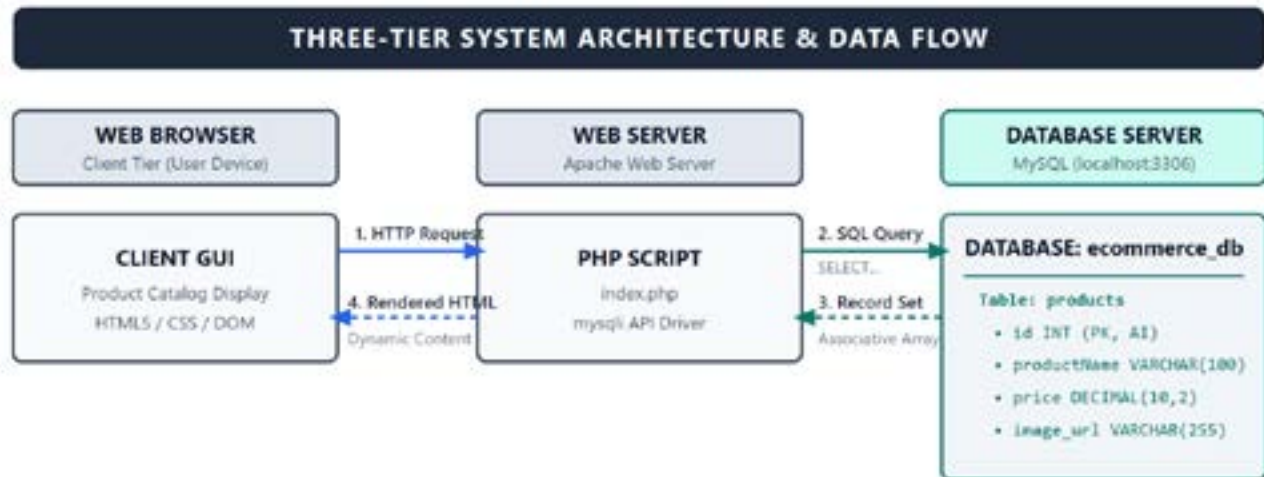


Figure 5.2 Connection between Database and Website

There is a need to connect to the web page can automatically display product information from the database.

Tools Required

- PHP (use XAMPP's built-in PHP server)
- A database with products already created

Connect the webpage to the database using the sample script

Sample PHP Script (index.php)

```
<?php
$conn = new mysqli("localhost", "root", "", "ecommerce_db");
echo $row['name'];
if ($conn->connect_error) {
    die("Connection failed: " . $conn->connect_error);
}
$sql = "SELECT name, price, image_url FROM products";
$result = $conn->query($sql);
    echo "<h1>Available Products</h1>";
    while ($row = $sql = "SELECT productName, price, image_url FROM products";
        $result = $conn->query($sql);
```

```

echo "<h1>Available Products</h1>";
while ($row = $result->fetch_assoc()) {
    echo "<div class='product'>";
    echo "<h3>" . $row['productName'] . "</h3>";
    echo "<p>Price: GHC " . $row['price'] . "</p>";
    echo "<img src='" . $row['image_url'] . "' alt='" . $row['productName'] . "' />";
    echo "</div>";
}
$conn->close();
?>

```

Run it using the following process

- a. Save the file as index.php.
- b. Place it in htdocs inside your XAMPP installation folder.
- c. Open your browser and go to:

<http://localhost/index.php>

You should see the product data pulled from the database!

Learning Tasks

1. Recap: Learners examine the structure of a pre-created e-commerce database, identifying tables, fields and relationships using weeks 11 activities.
2. Students analyse the provided sample PHP script, identifying key components that establish database connections and retrieve product information.
3. They create a flowchart illustrating how data moves from the database to the web page.
4. In groups, learners implement the sample PHP script to connect their e-commerce website (from week's 12 activities) to a database.
5. They modify the script to display products according to their chosen company or brand's needs.
6. Learners test their database-connected website, documenting any errors encountered and the steps taken to resolve them. They verify that all product information displays correctly from the database.
7. Learners reflect on the advantages of using a database-driven approach compared to hard-coding product information directly in HTML.

Pedagogical Exemplars

1. **Guided Discovery:** Begin with a demonstration of both a static HTML product page and a database-driven one. Have learners identify differences when products are added, modified, or removed. Guide them to discover the advantages of the database approach through questioning and observation.

Example Implementation

- a. Display two versions of the same e-commerce site side by side
- b. Make changes to product information and show how the database-driven site updates easily
- c. Ask learners to communicate the differences they observe

2. Scaffolded Practical Exercise

Provide learners with a partially completed implementation that includes:

- a. A pre-configured database with sample products
- b. The basic PHP connection code
- c. Commented sections where students need to add code to retrieve and display specific product information

Example Implementation

- a. Provide a template with clearly marked sections for learners' completion
 - b. Include detailed comments explaining what each section should accomplish
 - c. Offer three levels of support: beginner (mostly complete code), intermediate (partial code), and advanced (minimal code)
- 3. Grouping:** Organise learners into pairs with complementary skills - one with stronger database knowledge and one with stronger front-end development skills. Have them work together.

Key Assessment: Practice Paper 1

DoK Level 1

1. In the sample PHP script, which function is used to connect to the MySQL database?
 - A. `mysql_connect()`
 - B. `new mysqli()`
 - C. `connect_db()`
 - D. `database_link()`

DoK Level 2

2. If you wanted to display only products with a price less than \$50, how would you modify the SQL query?
 - A. `SELECT productName, price, image_url FROM products WHERE price < 50`
 - B. `SELECT productName, price, image_url FROM products IF price < 50`
 - C. `SELECT productName, price, image_url FROM products HAVING price < 50`
 - D. `SELECT productName, price, image_url FROM products FILTER price < 50`
3. List three parameters used in the `mysqli` connection in the sample code

Sample Expected answers:

- localhost
- root,
- ecommerce_db, etc.

Hint

Conduct **Practice Paper 1**. It should cover the contents taught from Year 1 to 3. Refer to the **Table of Specification and Structure of the Paper** at the end of this section to guide you. Learners' papers should be marked immediately and scores entered into the SAP.

TABLE OF SPECIFICATION

STRAND	SUB-STRAND	LEARNING OUTCOMES	CONTENT STANDARDS	LEARNING INDICATORS	LEVELS OF ASSESSMENT			
					1	2	3	4
STRAND 1 COMPUTER ARCHITECTURE AND ORGANISATION	Sub-Strand 1 DATA STORAGE AND MANIPULATION	1.1.1.LO.1 Apply Computer Architecture concepts related to the design of modern processors, memories, Input and Output to manipulate data. Types of architecture: (1) Von Neumann (2) Harvard (3) Instruction Set	1.1.1.CS.1 Demonstrate knowledge and understanding of data representation and data manipulation	1.1.1.LI.3 Discuss at least four major functions and the parts of the CPU; Arithmetic and Logic Unit (ALU), Control Unit (CU) and registers. 1.1.1.LI.4 Understand and explain the control bus, address bus, data bus and the internal clock, Machine Cycle, Fetch-Decode-Execute-Store Cycle, instruction set for a CPU and embedded systems.	One Question (Levels 1, 2, 3, 4)			
STRAND 1 COMPUTER ARCHITECTURE AND ORGANISATION	Sub-Strand 2 COMPUTER HARDWARE AND SOFTWARE	1.1.2.LO.1 Explain the relationships between the components of a computer and how data are transferred among the components. Explain types of Software and their functions.	1.1.2.CS.1 Demonstrate knowledge and understanding of components of Computer Hardware and Types of Software	1.1.2.LI.1 Explain the features of the hardware components of a computer (input hardware, processing hardware, output hardware, storage hardware and communication hardware).	One Question (Levels 1, 2, 3)			

		2.1.2.LO.1 Apply acquired skills and knowledge to explain the functioning of input and output devices in relation to barcodes and QR codes, as well as the functionality of an Operating System.	2.1.2.CS.1 Demonstrate knowledge and understanding of components of Computer Hardware and types of Software.	2.1.2.LI.1 Demonstrate the creation and utilisation of barcodes and QR codes using various input and output devices, such as monitors, system unit, processors, motherboards, hard disks, clock, mice, power unit and network interface cards for control and monitoring.	
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STRAND	SUB-STRAND	LEARNING OUTCOMES	CONTENT STANDARDS	LEARNING INDICATORS	LEVELS OF ASSESSMENT
STRAND 1 COMPUTER ARCHITECTURE AND ORGANISATION	Sub-Strand 2 COMPUTER HARDWARE AND SOFTWARE	3.1.2.LO.1 Explain the roles of Operating Systems and Utility Software as components of System Software, demonstrating an understanding of their functions. Perform the installation and management of an operating system, showcasing proficiency in the process.	3.1.2.CS.1 Demonstrate knowledge and understanding of components of Computer Hardware and Types of Software.	3.1.2.LI.1 Demonstrate the roles of Operating Systems and Utility Software as components of System Software.	One Question (Levels 2, 3)
STRAND 1 COMPUTER ARCHITECTURE AND ORGANISATION	Sub-Strand 3 DATA COMMUNICATION AND NETWORK SYSTEMS	1.1.3.LO.1 Use skills and knowledge to identify and differentiate between the different types of network systems. Examples: (1) LAN (2) WAN (3) MAN (4) Peer-To-Peer	1.1.3.CS.1 Demonstrate knowledge and understanding of network design. Components of computer networks examples: (1) Servers (2) Switches (3) Routers (4) Wireless (5) Cable.	1.1.3.LI.3 Differentiate among three Types of Network Systems.	
		2.1.3.LO.1 Apply skills and knowledge to design and demonstrate simple Network Topologies.	2.1.3.CS.1 Demonstrate knowledge and understanding of components of a network.	2.1.3.LI.2 Demonstrate how the system can connect to the Internet.	

		3.1.3.LO.1 Utilise knowledge of networking topologies to design and configure network systems to meet specific requirements.	3.1.3.CS.1 Demonstrate knowledge and understanding of components of a computer network as well as understanding their functions and uses.	3.1.3.LI.2 Demonstrate how network systems can connect to the Internet.	
STRAND 2 COMPUTATIONAL THINKING (PROGRAMMING LOG-IC)	Sub-Strand 1 ALGORITHM AND DATA STRUCTURE	1.2.1.LO.1 Apply knowledge of data structures to explain their real-life applications effectively.	1.2.1.CS.1 Demonstrate knowledge and understanding of Data Structures.	1.2.1.LI.2 Differentiate between the types of Data Structures.	One Question (Levels 1, 3, 4)
		2.2.1.LO.1 Apply skills in data storage processes to effectively manage and utilise data.	2.2.1.CS.1 Demonstrate knowledge and understanding of Data Storage.	2.2.1.LI.1 State and describe the functions of the main memory and central processing unit.	
		3.2.1.LO.1 Develop knowledge and skills in data storage technologies and their applications.	3.2.1.CS.1 Demonstrate knowledge and understanding of Data Storage.	3.2.1.LI.1 Identify, classify and discuss three Mass Storage media.	
	Sub-Strand 2 APP DEVELOPMENT	1.2.2.LO.1 Apply Algorithms in various real-life and programming situations or problems.	1.2.2.CS.1 Demonstrate knowledge and understanding of Computational Thinking (Algorithms and Programs). Usage of Python for programming.	1.2.2.LI.2 Implement Algorithms into program with the use of flowcharts, pseudocode and programming languages such as Python and HTML. Explain the steps in planning a program putting actions in the right order.	One Question (Level 2, 3, 4)

		2.2.2.LO.1 Demonstrate an understanding of fundamental concepts in text-based programming and the programming process, and apply acquired skills to create new functions.	2.2.2.CS.1 Demonstrate knowledge and understanding of Computational Thinking (Programming). Example is developing a simple calculator.	2.2.2.LI.2 Utilise simulation tools in Machine Learning to train a computer to perform specific actions or sets of actions.	
		3.2.2.LO.1 Explain the concept of Artificial Intelligence and its applications and use the knowledge acquired to distinguish between conventional systems and intelligent systems.	3.2.2.CS.1 Demonstrate knowledge and understanding of Computational Thinking (Artificial Intelligence)	3.2.2.LI.1 Describe the fundamental principles and components of Artificial Intelligence, such as machine learning, neural networks, and natural language processing. 3.2.3.LI.3 Analyse and compare the advantages and limitations of conventional systems and intelligent systems, considering factors such as problem-solving capabilities, adaptability, and learning capacity.	

Strand 2 COMPUTATIONAL THINKING (PROCED. PROGRAMMING)	Sub-Strand 3 WEB TECHNOLOGIES	1.2.3.LO.1 Explain the basic principles of web design and identify the modern technologies used in web design.	1.2.3.CS.1 Demonstrate knowledge and understanding of Web Development (HTML and CSS). (1) Procedures involve in hosting web pages. (2) Usage of appropriate servers. Example: mail server and database server.	1.2.3.LI.2 Draw and explain two Web Outline plans showing the wireframes	One Question (Level 1,2,3)
STRAND 2 COMPUTATIONAL THINKING (PROGRAMMING LOGIC)	Sub-Strand 3 WEB TECHNOLOGIES AND DATABASES	2.2.3.LO.1 Apply acquired skills and knowledge to design and develop simple web pages.	2.2.3.CS.1 Demonstrate knowledge and understanding of Web Development and Databases (SQL and Access)	2.2.3.LI.3 Create a relational database model of a database.	
	Sub-Strand 3 WEB TECHNOLOGIES	3.2.3.LO.1 Use skills and knowledge acquired to design simple web pages.	3.2.3.CS.1 Demonstrate knowledge and understanding of Web development.	3.2.3.LI.2 Design an e-commerce web page for a selected company or organisation: (1) Requirements to setup e-commerce (2) E-commerce models (3) Security of models (4) Payment systems (5) Product branding	
TOTAL NUMBER OF ESSAY ITEMS REQUIRED FOR THE TEST (6)					SIX (6)

D. TABLE OF TEST SPECIFICATION: PRACTICAL – PAPER THREE**1. INTRODUCTION**

This document gives an overview of instructions for Examiners of Paper 3 for Computing. It sets out the number of questions, their relation to the Content standards and sub-strands, and their relation to the depth of knowledge (DoK) levels.

The paper will consist of three (3) practical questions. Candidates must answer all three (3) questions for 60 marks; each question will carry 20 marks. The duration of the paper will be two hours thirty minutes.

2. PURPOSE

The table below sets out the Sub-Strands, Learning Outcomes, Content Standards, Learning Indicators (LIs) and DoK Assessment Levels derived from the Detailed Syllabus based on the Computing Curriculum. The final right-hand column indicates the number of items that should be selected from the set of LIs immediately to the left. The questions should weigh towards levels 2/3/4. A record of LIs/Levels used in each examination should be kept ensuring items are selected from different LIs /levels in different years.

STRAND	SUB-STRAND	LEARNING OUTCOMES	CONTENT STANDARDS	LEARNING INDICATOR	LEVELS OF ASSESSMENT
STRAND 2 COMPUTATIONAL THINKING (PROGRAMMING LOGIC)	Sub-Strand 2 APP DEVELOPMENT	1.2.2.LO.1 Apply Algorithms in various real-life and programming situations or problems.	1.2.2.CS.1 Demonstrate knowledge and understanding of Computational Thinking (Algorithms and Programs). Usage of Python for programming.	1.2.2.LI.2 Implement Algorithms into program with the use of flowcharts, pseudocode and programming languages such as Python and HTML. Explain the steps in planning a program putting actions in the right order.	One Question (Levels 2/3/4)
		2.2.2.LO.1 Demonstrate an understanding of fundamental concepts in text-based programming and the programming process, and apply acquired skills to create new functions.	2.2.2.CS.1 Demonstrate knowledge and understanding of Computational Thinking (Programming). Example is developing a simple calculator.	2.2.2.LI.1 Utilise a programming language to develop a program, such as a simple calculator. 2.2.2.LI.2 Utilise simulation tools in Machine Learning to train a computer to perform specific actions or sets of actions.	

STRAND 2 COMPUTATIONAL THINKING (PROCEDURAL PROGRAMMING)	Sub-Strand 3 WEB TECHNOLOGIES AND DATABASES	3.2.2.LO.1 Explain the concept of Artificial Intelligence and its applications and use the knowledge acquired to distinguish between conventional systems and intelligent systems.	3.2.2.CS.1 Demonstrate knowledge and understanding of Computational Thinking (Artificial Intelligence)	3.2.3.LI.3 Analyse and compare the advantages and limitations of conventional systems and intelligent systems, considering factors such as problem-solving capabilities, adaptability, and learning capacity.	
		1.2.3.LO.1 Explain the basic principles of web design and identify the modern technologies used in web design.	1.2.3.CS.1 Demonstrate knowledge and understanding of Web Development (HTML and CSS). (1) Procedures involve in hosting web pages. (2) Usage of appropriate servers. Example mail server and database server.	1.2.3.LI.2 Draw and explain two Web Outline plans showing the wireframes	One Question (Levels 2/3/4)

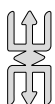
STRAND	SUB-STRAND	LEARNING OUTCOMES	CONTENT STANDARDS	LEARNING INDICATOR	LEVELS OF ASSESSMENT
STRAND 2 COMPUTATIONAL THINKING (PROGRAMMING LOGIC)	Sub-Strand 3 WEB TECHNOLOGIES AND DATABASES	2.2.3.LO.1 Apply acquired skills and knowledge to design and develop simple web pages.	2.2.3.CS.1 Demonstrate knowledge and understanding of Web Development and Databases (HTML, SQL and Access)	2.2.3.LI.1 Demonstrate the use of web page editors and design elements, including sections, text, images, GUI/UI/UX, and multimedia integration. 2.2.3.LI.3 Create a relational database model of a database.	One Question (Levels 2/3/4)
TOTAL NUMBER OF PRACTICAL ITEMS REQUIRED FOR THE TEST (3)					THREE (3)

PLC Session 12

45 minutes

Planning & Reviewing the Learning Plan

1. Begin the session by recapping lessons from the previous session, focusing on how learning was applied.
2. Use your subject specific app to explore the content before planning. Ask the app to
 - a. explain the week's concepts in a practical way that will make it easier for learners to understand.
 - b. identify three common misconceptions learners may have on the week's content and how to address them using contexts familiar to Ghanaian learners (NTS 3a, 3g and 3m).
3. Use your subject specific app to plan your lesson. Ask the app to
 - a. suggest the most effective method for teaching the week's concepts to learners with diverse backgrounds.
 - b. suggest learning activities, differentiation and essential questions based on the method of teaching (NTS 3a-3q).
 - c. review your prepared learning plan and address any challenging issues you may have identified in your subject area (NTS 3a-3c).



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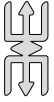
- Take note of the recap topics linked to Years 1 and 2 while preparing for your lesson.
- Refer to the Values Learning Community Handbook and link the values for the week in your lesson to ensure that learners are applying what they learn.

4. Use your app to plan and administer the mode of assessment for the Student Assessment Portal (SAP).
 - a. The key assessment for the week is **Practice Paper 1**. Chat with your app to plan this assessment by reviewing or developing the assessment items/tasks and marking schemes/rubrics for the practice paper (NTS 3k-3q).

10 minutes

Content Exploration

5. As a subject group, select one problem or topic/idea/term in the week's content that is challenging (not a routine procedural question, but one that requires conceptual understanding) and then
 - a. use the app, ask it to solve the problem step by step and explain the reasoning behind each step (you may be assisted by a teacher who is strong in the content area)
 - b. all teachers in the group work through the problem individually for 3–4 minutes
 - c. the group then works through it together the problem, step by step
 - d. highlight the most common errors made at each step (NTS 1c, 1e, 2c, 2e, 3e-3j).



Note

- This part is not ‘How do I teach this?’ but how do I teach it for learners to understand?
- If the group still shares the same content gap, use the app: ask it to solve the problem step by step and explain the reasoning behind each step.
- Problems/ideas discussed should be sourced from the Teacher Manual content, not invented separately. This keeps the content exploration directly connected to what teachers will deliver.

30 minutes

Enactment

6. Enact a teaching activity based on your learning plan (NTS 1a-1b, 1e-1g, 2c, 2e, 2f, 3c-3j and 3o).
 - a. Colleagues observe with specific attention to clarity of concept explanation, use of familiar Ghanaian examples and how misconceptions are handled if they arise.
 - b. After the enactment, ask for structured feedback from the group
 - i. was the concept explained in a way that a learner with no prior knowledge could follow?
 - ii. were the examples grounded in contexts familiar to Ghanaian learners?
 - iii. did any misconceptions surface and if so, how were they addressed?

5 minutes

Reflection

7. Reflect and share your views on the session. One thing that worked well, what did not work well and what you will do differently. (NTS 1a, 1b).
8. Identify a critical friend to observe and provide feedback on your lesson in relation to the PLC Session conducted (NTS 1f, 1g).
9. Remember to
 - a. transfer your chats into your learning planner template.
 - b. read your Teacher Manual and related Learner Material in preparation for the next session. Take note of the recap weeks, which are linked to Years 1 and 2 (NTS 3a).
 - c. integrate National Values, GESI, SEL, and 21st century skills into your learning activities, assessment tasks, and rubrics/mark schemes.

WEEK 13

Learning Indicator: *Understand and Apply Basic Cyber Security Best Practices*

FOCAL AREA 1: UNDERSTANDING CYBERSECURITY THREATS

Cybersecurity is protecting computers, networks, mobile devices and data from digital attacks, theft or damage. In Ghana's rapidly growing digital economy, cybersecurity is important for:

1. Mobile Money security
2. Online banking
3. E-commerce
4. Government digital services and more.

Let us explore some common cyber threats in Ghana:

1. Mobile Money Fraud
 - a. SIM card swapping: Criminals get duplicate SIM cards to access your mobile money
 - b. Fake USSD codes: Fraudulent messages asking you to dial codes that steal money such as (Congratulations! You have won 5,000 cedis. Dial *170*9*PIN# to claim now).
 - c. Social engineering: Scammers pretending to be telco staff to get your PIN
 - d. Emergency Fraud: Scammers pretend to be nurses or teachers and call parents whose wards are in the boarding school that their wards are sick and needs urgent with some amount of money.
2. Online Shopping Scams
 - a. Fake e-commerce sites: Websites that take your money but never deliver goods/service you purchased.
 - b. Social media scams: Facebook/Instagram sellers who disappear after payment
 - c. Too-good-to-be-true deals: iPhone 14 for 500 cedis on WhatsApp
3. Phishing Attacks
 - a. Fake bank emails: Messages claiming your account is blocked, asking for login details
 - b. Government impersonation: Fake messages about tax payments or fines
 - c. Academic scams: Fake WASSCE results or university admission offers



Figure 6.1 Phishing Attacks Process

4. Ransomware and Malware

- School computer infections: Viruses that lock computers until payment is made
- USB-spread malware: Infected flash drives that steal data
- Fake apps: Mobile apps that steal personal information

Why Ghana is Vulnerable

- Rapid digital adoption: without corresponding security awareness
- Limited cybersecurity education in schools and communities
- High smartphone usage with low security knowledge
- Trust-based culture that scammers exploit

FOCAL AREA 2: PASSWORD SECURITY AND AUTHENTICATION

Common Password Mistakes

In Ghana, it is common for personal details like full names, dates of birth and phone numbers to be easily accessible (e.g., from social media profiles, public records or even direct requests during registration processes). Cybercriminals can quickly guess these, especially if they know a bit about you.

Examples of some common password practices we engage in are:

- Using short common character like “Ghana123” or “Accra2024” as passwords
- Same password for mobile money, email and social media
- Sharing passwords with family members for “convenience”
- Using easily guessed information (birthdate, phone number, Ghana Card number or even your favourite football team)

Strong Password Strategies

To strengthen a password, it is best to follow this suggested practice.

- Password Creation Method:

- a. Length: Minimum 12 characters
- b. Complexity: Mix of uppercase, lowercase, numbers, symbols
- c. Uniqueness: Different password for each account
- d. Memorability: Use Ghanaian phrases or songs

Example: “ILoveGhanaFuFu2024!” (combines patriotism, local food, year, symbol)

2. Two-Factor Authentication (2FA)

What it is: Second verification step beyond password. It works by combining Password + SMS code or app code. For example, the following applications make use of 2FA.

- a. Bank apps (GCB, Ecobank mobile banking)
- b. Email accounts (Gmail, Yahoo)
- c. Social media (Facebook, WhatsApp Business)

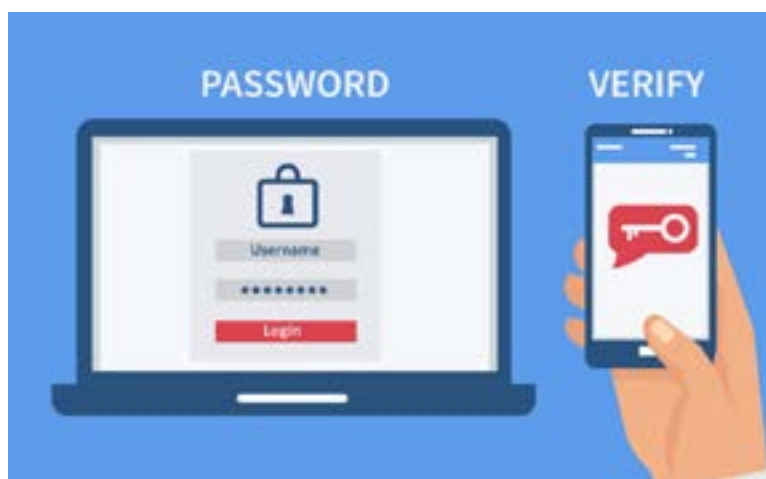


Figure 6.2 2FA verification

Learning Tasks

1. Learner's research and create an awareness campaign material on cybersecurity for different communities. Using the following types of cyber threats
 - a. Mobile money fraud targeting market traders
 - b. Social media scams targeting students
 - c. Email phishing targeting office workers
 - d. Online shopping scams targeting urban consumers

The deliverables for the campaign should cover

 - a. Real examples of the threat from Ghanaian context
 - b. How the scam works step-by-step
 - c. Who is most vulnerable and why
 - d. Warning signs people should watch for
 - e. Prevention strategies specific to Ghana

2. Evaluate these common Ghanaian passwords by identify its strength and the problem with the password if any. Suggest an improved password where necessary.

Password	Strength			Problem	Improvement
	W	M	S		
ghana123					
MyPhone0244					
ILoveAccra&Ho2023					
Kotoka@Airport15					
KumaSi2024!					

3. Create strong passwords for these scenarios:

- Mobile money account for a market trader in Tamale
- University email for a student at University of Ghana
- Online banking for a teacher in Cape Coast
- Social media account for a young entrepreneur in Kumasi

Note: you can use this link to verify the strength of your password (<https://www.passwordmonster.com/>)

Pedagogical Exemplars

- Direct Instruction: Teacher facilitates an open class discussion with learners about cyber security and common threats.
- Collaborative Research and Project-Based Learning: Teacher guides learners to work in their groups to research and create campaign awareness materials on cyber threats.
- Exploratory Learning: Teacher guides learners to evaluate the given passwords in task 2 and validate their created password for task 3 with the use of a password strength checker.

Key Assessment: Case Study

DoK Level 1

- What does cybersecurity mean?

DoK Level 2

- Why is Ghana particularly vulnerable to cybersecurity threats? Give two reasons. (2 marks)

DoK Level 3

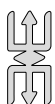
- A market trader in Kumasi receives a WhatsApp message claiming to be from MTN, asking her to verify her mobile money account by sharing her PIN. Analyse this situation and recommend what she should do. (4 marks)

PLC Session 13

45 minutes

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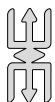
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4. Plan the week's key assessment with your app
 - a. The key assessment for the week is **case study**. Chat with your app to plan this assessment, indicating what you and your learners will do before, during and after the case study (NTS 3k-3q).

10 minutes

Content Exploration

5. As a subject group, select one problem or idea/term in the week's content that is challenging (not a routine procedural question, but one that requires conceptual understanding) and then
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WEEK 14

Learning Indicator: *Understand and Apply Basic Cyber Security Best Practices*

FOCAL AREA 1: SMARTPHONE SECURITY PRACTICES

It is important for mobile phone users to ensure that their mobile devices have good security features activated to prevent cyber threats.

1. Device Lock Security:
 - a. Screen locks: PIN, pattern, fingerprint, face unlock
 - b. Auto-lock timing: 1-2 minutes maximum
 - c. Lock screen information: Limit what's visible when locked
2. App Security:
 - a. Official app stores: Google Play Store, Apple App Store
 - b. App permissions: Review what apps can access
 - c. Regular updates: Keep apps and OS updated
 - d. App removal: Delete unused apps
3. Mobile Money Security:
 - a. PIN protection: Never share your mobile money PIN
 - b. Transaction verification: Always check recipient details
 - c. Balance monitoring: Regular balance checks
 - d. Secure networks: Avoid public Wi-Fi for financial transactions

FOCAL AREA 2: PERSONAL DATA PROTECTION

Personal data refers to any information that can be used to identify you, directly or indirectly. It is not just your name; it is a wide range of details that, when combined, paint a picture of who you are.

Types of Personal Data Commonly Shared

1. Identity Information

Name, Age, Hometown, School: These are foundational pieces of information. In Ghana, your full name, age and place of origin (hometown) are often requested for various registrations and school affiliations are common.

This data matters because it helps verify who you are but can also be used for targeted scams or identity theft if it falls into the wrong hands.

2. Contact Details

Phone Number, Email, Residential Address: These are important for communication. Given the high mobile penetration in Ghana, phone numbers are particularly vital and are used for everything from mobile money to service registrations.

3. Financial Information

Mobile Money PIN, Bank Details (Account Numbers, Card Details). This information are highly sensitive data that directly relates to your money. Mobile money is ubiquitous in Ghana, making PINs and transaction details very attractive to fraudsters. Compromise of this data can lead to direct financial loss through unauthorised transactions or account access.

4. Biometric Data

Fingerprints (for phone unlock, bank access), Facial Scans (increasingly for verification): With the widespread use of smartphones and the implementation of biometric verification for services like SIM card registration, bank accounts and even the Ghana Card, your unique biological identifiers are now digital data points. Biometric data is unique and permanent. If compromised, it cannot be changed like a password, making its security paramount.

5. Location Data

Where you go, when you travel (via phone GPS, app usage): Your smartphone constantly tracks your location, which apps often request access to. This data can reveal your daily routines, frequented places and travel habits.

6. Social Information

Friends, Family, Relationships (from social media, contact lists): The connections you have online and in your phone, contacts reveal a lot about your social network.

Ghana's Data Protection Act (2012): Rights and Protections

The Data Protection Act (Act 843) of 2012 is Ghana's legal framework designed to protect your personal data. It establishes rules for how organizations collect, use, store and disclose your information.

Key Rights of Ghanaians Under the Act

1. **Right to Know What Data is Collected:** You have the right to be informed about what personal data an organisation is collecting about you, why they are collecting it and how they intend to use it. This ensures transparency.
2. **Right to Correct Wrong Information:** If your data held by an organisation is inaccurate or incomplete, you have the right to request that it be corrected or updated. This is important for maintaining accurate records, especially for official documents or financial services.
3. **Right to Delete Your Data (Right to Erasure):** In certain circumstances, you have the right to request that your personal data be deleted or removed. For instance, if the data is no longer necessary for the purpose it was collected or if you withdraw your consent.
4. **Right to Limit How Data is Used (Right to Restriction of Processing):** You can request that an organisation restrict or stop processing your data under certain conditions, for example, if you dispute the accuracy of the data.

5. **Right to Move Your Data to Another Service (Right to Data Portability):** This right allows you to obtain and reuse your personal data for your own purposes across different services. It promotes competition and makes it easier to switch service providers.
6. **Right to Object to Processing:** You have the right to object to the processing of your data in specific situations, such as for direct marketing purposes.

Organisations in Ghana that **MUST** Protect Your Data Under the Act

The Data Protection Act applies to almost every entity that processes personal data. This includes:

1. **Banks and Financial Institutions:** They handle highly sensitive financial information, mobile money details and investment data. Compliance is vital for financial security.
2. **Telecommunications Companies:** Collect vast amounts of data including your call records, SMS, data usage, location and registration details (e.g., Ghana Card information for SIM registration).
3. **Schools and Universities:** They hold personal details, academic records, health information, and family contacts of students and staff.
4. **Government Agencies:** All government bodies that collect citizen data – from the National Identification Authority (NIA) and Ghana Revenue Authority (GRA) to ministries and local assemblies – are bound by the Act.
5. **Online Businesses (E-commerce, Social Media Platforms, Apps operating in Ghana):** Any company that collects data from Ghanaians through websites, apps, or online services must comply, regardless of where their servers are located. This includes online retailers, food delivery services, and ride-hailing apps.
6. **Hospitals and Healthcare Providers:** They handle extremely sensitive medical and health information.

Learning Tasks

1. Audit your phone or parents' phones using this checklist
 - Screen lock enabled (PIN/pattern/biometric)
 - Auto-lock set to 2 minutes or less
 - Apps only from official stores
 - Mobile money app has additional PIN
 - Bluetooth set to non-discoverable
 - Location services reviewed and limited
 - Regular backups enabled
 - Find My Phone/Device Manager enabled
2. WhatsApp hacking has become a major cybersecurity threat in Ghana. As a computer science student with knowledge of cyber threats, create a campaign guide to educate persons 40+ years about this threat.
3. Learners discuss the cyber security policy of Ghana.

Pedagogical Exemplars

1. Project-based learning: Teacher guides learners to audit their phones and also create a campaign for WhatsApp hacking in Ghana.
2. Discussion: Teacher facilitates discussion about the cyber security policy of Ghana.

Key Assessment: Case Study

DoK Level 2

1. Explain why software updates are important for organisational cybersecurity. (2 marks)
2. Explain how two-factor authentication works using a Ghana banking example. (2 marks)

DoK Level 3

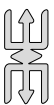
3. A Ghanaian university student discovers that a fake social media profile is using her photos and personal information. Analyse this situation and recommend a comprehensive response strategy. (5 marks)

PLC Session 14

45 minutes

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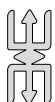
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Section Review

This section equipped learners with comprehensive competencies in full-stack web architectures, dynamic database integration, and digital security practices. Learners designed e-commerce catalog interfaces using semantic HTML and CSS, constructed normalized relational databases in MySQL, and established dynamic data pipelines using PHP server-side scripting.

Additionally, the section integrated critical cybersecurity principles tailored to the Ghanaian digital ecosystem. Learners evaluated threat vectors including Mobile Money fraud, social engineering, and phishing schemes, while applying robust defense mechanisms such as high-entropy password strategies and multi-factor authentication (2FA). Furthermore, learners explored mobile endpoint security hygiene, application permission audits, and citizen rights and corporate compliance obligations under Ghana's Data Protection Act (Act 843) of 2012. These combined technical and security proficiencies prepare learners to build resilient, legally compliant digital platforms.

MARKING SCHEMES FOR THE KEY ASSESSMENTS

WEEK 10

1. B
2. B
3. **Expected Answer:** The four main components of a relational database are:
 - a. Tables: Collections of related data entries arranged in rows and columns
 - b. Fields (Columns): Categories of information stored in tables
 - c. Records (Rows): Individual entries in a table containing data
 - d. Keys: Special fields used to identify records and establish relationships between tables

WEEK 11

1. B
2. C
3. Rubric for question 3

Criteria	Excellent (4)	Good (3)	Satisfactory (2)	Needs Improvement (1)
----------	---------------	----------	------------------	-----------------------

HTML Structure	Description has a structural HTML code for adding price elements and buttons to each product	Description has a structural HTML code for adding either price elements or buttons to each product	Description has HTML code for adding either price elements or buttons to each product without a structure	Mentions HTML code is needed for adding either price elements or buttons to each product without description.
CSS Styling	Includes 4 appropriate CSS properties for styling prices and buttons (colour, padding, margin, font-size)	Includes 3 appropriate CSS properties for styling	Includes 2 appropriate CSS properties for styling	Includes 1 appropriate CSS property for styling

WEEK 12

1. B
2. A

WEEK 13**Question 1****Sample Expected Answer**

Protecting computers, networks, mobile devices, and data from digital attacks, theft, or damage.

Question 2**Sample Expected Answer**

- a. Rapid digital adoption without corresponding security awareness (1 mark)
- b. Trust-based culture that scammers exploit (1 mark)

Question 3**Expected Answer**

- a. This is a social engineering/phishing attack (1 mark)
- b. MTN would never ask for PIN via WhatsApp (1 mark)
- c. She should not share her PIN and should report the message (1 mark)
- d. She should verify by calling MTN customer service directly (1 mark)

WEEK 14**Question 1****Expected Answer**

- a. Updates include security patches that fix vulnerabilities (1 mark)
- b. Outdated software can be exploited by cybercriminals (1 mark)

Question 2**Expected Answer**

- a. First factor: Password to log into GCB mobile app (1 mark)
- b. Second factor: SMS code sent to registered phone number (1 mark)

Question 3**Expected Answer**

- a. Immediate action: Report fake profile to social media platform (1 mark)
- b. Evidence collection: Screenshot fake profile and document misuse (1 mark)
- c. Legal action: Report to Ghana Police Cybercrime Unit (1 mark)
- d. Prevention: Adjust privacy settings, limit public information (1 mark)
- e. Monitoring: Regular checks for future misuse of identity (1 mark)

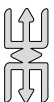
Hint

Conduct **Practice Paper 2 on Week 18**. It should cover the contents taught from Year 1 to 3. Refer to the **Table of Specification and Structure of the Paper** at the end of this section to guide you. Learners' papers should be marked immediately and scores entered into the SAP.

PLC Session 18**45 minutes**

Planning & Reviewing the Learning Plan

1. Begin the session by recapping lessons from the previous session, focusing on how learning was applied.
2. Use your subject specific app to explore the content before planning. Ask the app to
 - a. explain the week's concepts in a practical way that will make it easier for learners to understand.
 - b. identify three common misconceptions learners may have on the week's content and how to address them using contexts familiar to Ghanaian learners (NTS 3a, 3g and 3m).
3. Use your subject specific app to plan your lesson. Ask the app to
 - a. suggest the most effective method for teaching the week's concepts to learners with diverse backgrounds.
 - b. suggest learning activities, differentiation and essential questions based on the method of teaching (NTS 3a-3q).
 - c. review your prepared learning plan and address any challenging issues you may have identified in your subject area (NTS 3a-3c).

**Note**

- Take note of the recap topics linked to Years 1 and 2 while preparing for your lesson.

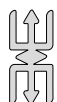
- *Refer to the Values Learning Community Handbook and link the values for the week in your lesson to ensure that learners are applying what they learn.*

4. Use your app to plan and administer the mode of assessment for the Student Assessment Portal (SAP).
 - a. The key assessment for the week is **Practice Paper 2**. Chat with your app to plan this assessment by reviewing or developing the assessment items/tasks and marking schemes/rubrics for the practice paper (NTS 3k-3q).

10 minutes

Content Exploration

5. As a subject group, select one problem or topic/idea/term in the week's content that is challenging (not a routine procedural question, but one that requires conceptual understanding) and then
 - a. use the app, ask it to solve the problem step by step and explain the reasoning behind each step (you may be assisted by a teacher who is strong in the content area)
 - b. all teachers in the group work through the problem individually for 3–4 minutes
 - c. the group then works through it together the problem, step by step
 - d. highlight the most common errors made at each step (NTS 1c, 1e, 2c, 2e, 3e-3j).

**Note**

- This part is not 'How do I teach this?' but how do I teach it for learners to understand?
- If the group still shares the same content gap, use the app: ask it to solve the problem step by step and explain the reasoning behind each step.
- Problems/ideas discussed should be sourced from the Teacher Manual content, not invented separately. This keeps the content exploration directly connected to what teachers will deliver.

30 minutes

Enactment

6. Enact a teaching activity based on your learning plan (NTS 1a-1b, 1e-1g, 2c, 2e, 2f, 3c-3j and 3o).
 - a. Colleagues observe with specific attention to clarity of concept explanation, use of familiar Ghanaian examples and how misconceptions are handled if they arise.
 - b. After the enactment, ask for structured feedback from the group
 - i. was the concept explained in a way that a learner with no prior knowledge could follow?
 - ii. were the examples grounded in contexts familiar to Ghanaian learners?
 - iii. did any misconceptions surface and if so, how were they addressed?

5 minutes

Reflection

7. Reflect and share your views on the session. One thing that worked well, what did not work well and what you will do differently. (NTS 1a, 1b).

- 8.** Identify a critical friend to observe and provide feedback on your lesson in relation to the PLC Session conducted (NTS 1f, 1g).
- 9.** Remember to
 - a.** transfer your chats into your learning planner template.
 - b.** read your Teacher Manual and related Learner Material in preparation for the next session. Take note of the recap weeks, which are linked to Years 1 and 2 (NTS 3a).
 - c.** integrate National Values, GESI, SEL, and 21st century skills into your learning activities, assessment tasks, and rubrics/mark schemes.

REFERENCES

1. GeeksforGeeks. (n.d.). Three layer hierarchical model in Cisco. Computer Networks. Retrieved from <https://www.geeksforgeeks.org/computer-networks/three-layer-hierarchical-model-in-cisco/>
2. iStock. (n.d.). Bus topology [Stock images]. Retrieved from <https://www.istockphoto.com/search/2/image-film?phrase=bus+topology>