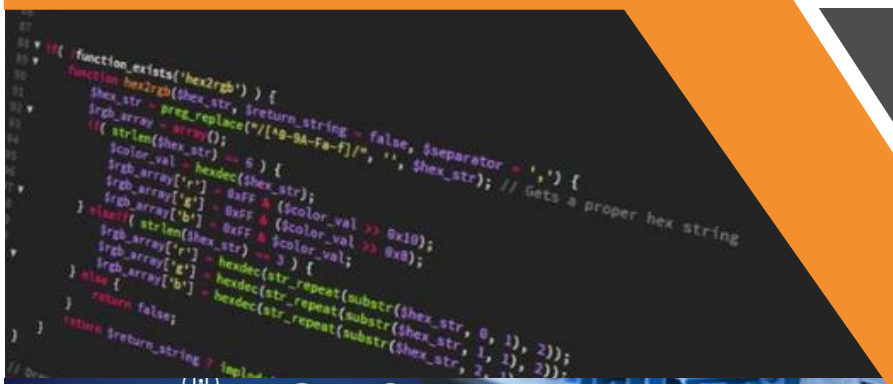
Republic of Rwanda
Ministry of Education

RTB | RWANDA TVET BOARD

CURRICULUM STRUCTURE



RQF LEVEL 4

TVET CERTIFICATE IV
in
SOFTWARE PROGRAMMING AND EMBEDDED SYSTEMS

ICTSPE4002

Kigali, August 2023

ICTSPE4002 TVET CERTIFICATE IV

Funded by:

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LIST OF ABBREVIATIONS

CLI: Command-Line Interface

CRUD: Create Read Update Delete

ICT: Information Communication Technology

IDE: Integrated development environment

IT: Information Technology

NST1: National Strategic Transformation 1

RQF: Rwanda Qualification Framework

RTB: Rwanda TVET Board

SDG: Sustainable Development Goals

SEO: Search Engine Optimization

SVG: Scalable Vector Graphics

TQUM: TVET Quality Management

TVET: Technical Education and Vocational Training

UI: User Interface

UX: User Experience

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FOREWORD

The global rapid changes in the labour market tends to call for appropriate training and skills development through outcome-based training approaches. Skills development and employment promotion are central to Rwanda's transformative Vision 2050, aiming to secure high standards of living for all Rwandans. In a bid to transform Rwanda into a knowledge-based economy, the National Strategic Transformation 1 (NST1) calls socio-economic transformation through TVET skills development. The Rwanda TVET Board (RTB) was established to promote quality education in technical and vocational education and training from level one (1) to five (5) aimed at fast tracking socio-economic development of the country. Designing and distributing curricula, teaching materials, trainer's guides, methodologies and establishing training methods for technical and vocational education and training from level one (1) to five (5); is among other RTB's responsibilities.

Some of the existing curricula were combined and reviewed to have capacity in terms of acquired skills and knowledge and meeting the requirements of the current labour market at both national and regional level. In addition, there were barriers in vertical mobility and pathways in TVET which resulted in negative TVET perception before combining both trades. Furthermore, there were barriers to admission of TVET graduates of certain programs into higher learning institutions.

The TVET modernization process has begun with a clear picture of the programs focusing on sectors with highly increasing market demand such as software development to name a few. In this regard, Rwanda TVET Board, in collaboration with TQUM Project, is honoured to avail the curriculum of Software Development which serves as the official document and respond to the above-mentioned concerns.

With the help of the training providers, trainers, parents whose role is central to the success of this curriculum, the trainees will gain appropriate hand on skills which will make a difference not only to their own lives but also to the success of Rwanda's economy.

I wish to sincerely extend my appreciation to the people who contributed towards the development of this document.

Dipl._Eng. Paul UMUKUNZI

Director General/ RTB

GENERAL INTRODUCTION

The curriculum presents a coherent and significant set of competencies to perform the occupation/s of full-stack developer, Web3 Developer, Blockchain Developer, NFT Developer, Smart Contract Developers, Database Administrator, and Network administrator. It is designed with an approach that takes into account the training needs, the work situation, as well as the goals and the means to implement the training.

The modules of the curriculum include a description of the expected results of the training. They have a direct influence on the choice of theoretical and practical learning activities. The competencies are the targets of the training: the acquisition of each is required for certification.

The curriculum is the reference to carry out the assessment of learning whose assessment tools of learning are developed based on this document.

The curriculum consists of three parts. The first part is of general interest and shows the nature and goals of the program and the key concepts and definitions used in the document. The second part presents the qualification, its level in the qualification framework, its purpose, its rationale and the list of modules it comprises. The third part deals with the training package. It includes the sequencing of module learning, the description of each module and the course structure.

The pages describing the modules are the heart of a curriculum. They present the title of the module, the length of training, the number of credits, the context in which the competency is performed, the prerequisite competencies, the learning outcomes and the performance criteria.

In each module, a course structure is provided. The course structure describes the learning outcomes (knowledge, skills and attitudes) and the learning contents related to each learning outcome. In addition, the learning activities and resources for learning are suggested.

Finally, the assessment specifications and guidelines are included in each module.

QUALIFICATION DETAILS

Description

Title:	TVET Certificate 4 in Software Programming and Embedded Systems
Level:	RQF Level 4
Credits:	120
Sector:	ICT and Multimedia
Sub-sector:	Software Programming and Embedded Systems
Issue date:	September, 2023

Graduate profile

This qualification provides the skills, knowledge and attitudes for a learner to be competent in a range of routine tasks and activities that require the application of practical skills in a defined context. Work would be undertaken in various Software Development fields/industries including Backend developer, full-stack developer, Web3 Developer, Blockchain Developer, NFT Developer, Smart Contract Developer, Database Administrator, and Network administrator. Learners may work with some autonomy or in a team but usually under regular supervision.

At the end of this qualification, qualified learners will be able to:

1. Apply Mathematics
2. Apply Advanced Technical English
3. Apply Physics
4. Apply Data Structure and Algorithms using C++
5. Integrate embedded systems software
6. Perform advanced networking
7. Develop Web3 application
8. Apply software engineering
9. Apply fundamentals of Object Oriented Programming with Java
10. Develop advanced database
11. Develop Software using Advanced Java
12. Develop 3D models
13. Develop a project (IA)

1.1 Minimum entry requirements and pathways

The minimum entry requirement to this course is to have a genuine interest and have completed Level 3(L3) in Software Programming and Embedded Systems and related areas.

	Pathways into the qualification	Pathways from the qualification	
	▪ To be admitted, prospective candidates should be attended at least level III in Software programming and Embedded systems trade.	Progression route of candidates achieving this qualification include: ▪ TVET Certificate V in Software programming and Embedded systems trade	

1.2 Rationale of the qualification

The ICT sector in Rwanda is contributing 2.5% to the country's GDP in 2023. This represents a growth of 10% from 2022. Amongst the main drivers of growth is immerging technologies for IT services, which is expected to grow by 8%.

This training curriculum seeks to capitalize on emerging technologies such as Web3, blockchain, immersive tech, AI, and embedded systems to drive Rwanda's digital economy forward. With a focus on empowering its tech-savvy population, the curriculum aims to equip learners with the knowledge and skills to navigate and leverage these technologies effectively.

Blockchain is highlighted as a means to secure and transparently record transactions, particularly valuable for tracking land ownership and payments in Rwanda. Immersive technologies like AR and VR are seen as tools to create engaging user experiences, with applications in education, tourism, and recreation. AI's automation capabilities are central to improving efficiency and driving innovation in businesses, ultimately boosting economic growth. Embedded systems, especially in sectors like agriculture and healthcare, play a vital role in data collection and machine control.

In Rwanda, the integration of cutting-edge technologies is ushering in a new era of progress across various sectors. In agriculture, Rwandan farmers are harnessing the power of immersive technologies to optimize crop management, improve yields, and enhance resource utilization. Artificial intelligence (AI) is automating labor-intensive tasks like weeding, promoting efficiency and sustainability in the country's vital agricultural sector. Furthermore, the educational landscape is evolving with immersive technologies creating engaging learning environments, while AI personalizes education to meet the unique needs of students. The exploration of blockchain for secure educational records aligns with Rwanda's commitment to improving access to quality education, paving the way for a brighter future.

Rwanda's healthcare system is leveraging AI for disease diagnosis and treatment recommendations, especially in remote areas where healthcare access is limited. Concurrently, blockchain technology is ensuring the security and integrity of medical records, enhancing patient care and management. In manufacturing, AI-driven automation is boosting production efficiency, contributing to Rwanda's efforts to strengthen its local manufacturing industry. The implementation of blockchain solutions for supply chain tracking supports the country's drive for product authenticity and quality assurance. Additionally, Rwanda's financial services sector is exploring blockchain for secure and efficient transactions, while AI is enhancing fraud detection and providing personalized financial advice. The government is embracing blockchain for transparent record-keeping and utilizing AI to combat corruption and enhance the delivery of

public services, aligning with Rwanda's commitment to good governance and economic growth. As Rwanda continues to embrace these innovative technologies, it is positioning itself as a hub for technological advancement and sustainable development on the African continent.

Overall, this curriculum strives to foster a digital economy in Rwanda that is efficient, secure, and inclusive, while also creating new employment opportunities for its citizens.

1.2 Job related information

This qualification prepares individuals to integrate in all types of ICT companies from small to big, private to public that require ICT related services with the professionalization of Software Development and can even work for themselves.

	**Possible jobs related to this qualification**
	1. Full stack developer 2. Backend Developer 3. Web3 Developer, 4. Database Administrator, 5. Network administrator, 6. Blockchain Developer, 7. NFT Developer, 8. Smart Contract Developer 9. 3D model developer

1.3 Information about competencies

No	Code	Cross-cutting competencies	Credit
1.	CCMBC402	Develop a Business plan	3
2.	CCMKN402	Gukoresha ikinyarwanda cy'umunyamwuga	3
3.	CCMCZ301	Promote the culture of peace	3
Total			**9**

No	Co-Curricular activities	Credit
1.	Sports/clubs	2
2.	Self-study/ library research	2
Total		4

	No	Code	Core competencies	Credit
GENERAL	1.	GENMA401	Apply Mathematics	**10**
	2.	GENEG401	Apply Advanced Technical English	**8**
	3.	GENPA401	Apply Physics	**10**
SPECIFIC	4.	SPEDS402	Apply Data Structure in Problem Solving with C++	**11**
	5.	SPEES402	Develop embedded system software	**8**
	6.	SPEED402	Perform Advanced Database development	**5**
	7.	SPEJO402	Appy fundamentals of Object-Oriented Programming with Java	**11**
	8.	SFPDW402	Develop Web3 Application	**5**
	9.	SFPAN402	Perform Advanced Networking	**8**
	10	SPESE402	Apply Software Engineering	**10**
	11	SPE3D401	Develop 3D models	**5**
	12	SFPAJ402	Develop Software Using Advanced Java	**12**
	13	SPEPL401	Develop a Project	**8**
	Total			**111**

1.4 Allocation of Learning Hours

N0	Module name	Learning Outcome	Theoretical hours	Practical hours	Total hours
4	Data Structures and Algorithms using C++	LO1: Apply C++ programming concepts.	3	7	10
		LO2: Analyze data structure and algorithms	5	5	10
		LO3: Implement Linear Data Structure	10	30	40
		LO4: Implement Non Linear Data Structure	7	18	25
		LO5: Implement Hash Table and handle Data Retrieval	3	7	10
		LO6: Apply recursion for solving complex problems using C++	4	11	15
Total hours			30	80	110
5	Software engineering	LO1: Manage software requirements and analysis	10	10	20
		LO2: Design system	10	15	25
		LO3: Perform Software Testing	10	15	25
		LO4: Manage Software Project	15	10	25
		LO5: Elaborate Software Ethics and Professionalism	5	0	5
Total hours			50	50	100
6	Embedded systems Software Integration	LO1: Develop Embedded Systems Firmware	8	16	24
		LO2: Integrate Peripherals with Microcontroller	10	22	32
		LO3: Communicate data over the network	8	16	24
Total hours			32	48	80
7	Advanced Database Development	LO1: Design database	5	8	13
		LO2: Perform advanced Database manipulation	4	16	20
		LO3: Secure Database	2	6	8
		LO4: Configure DBMS	2	7	9
Total hours			10	40	50
8	Fundamentals OOP with Java	LO1: Describe Java basics	3	7	10
		LO2: Implement Object Oriented Programming	15	25	40
		LO3: Apply enums, design patterns, regular expression and multithreading.	5	10	10

		LO4: Develop Graphical User Interfaces	10	10	20
		LO5: Apply Java Network Programming	4	6	10
		LO6: Apply Java Database Connectivity	6	14	20
Total hours			38	72	110
9	Web3 application Development	LO1: Design blockchain system architecture	3	6	9
		LO2: Develop blockchain application	3	11	14
		LO3: Develop Smart contracts system	3	11	14
		LO4: Develop frontend for decentralized applications(Dapps) using web3	3	13	16
Total hours			12	41	53
10	Advanced Networking	LO1: Configure routing protocols	5	7	12
		LO2: Configure VLANs, VTP, STP, and switch security	6	12	18
		LO3: Implement Inter-VLAN routing	8	22	30
		LO4: Configure wireless and WAN networks	4	16	20
Total hours			22	58	80
11	Advanced Java	LO1: Apply Java Web Application Technologies	7	18	25
		LO2: Develop Backend using Java	17	28	45
		LO4: Build microservices	5	30	35
		LO5: Manipulate file-based data	5	10	15
Total hours			27	93	120
12	Development of 3D Models	LO1: Analyze 3D concept	5	0	5
		LO2: Design 3D Models	5	16	20
		LO3: Animate 3D model	4	11	15
		LO4: Print 3D object	3	7	10
Total hours			17	33	50
13	Develop a project	LO1: Set a project purpose	5	15	20
		LO2: Develop a project Plan	10	30	40
		LO3: Evaluate Implemented project.	5	15	20
Total hours			17	33	80

TRAINING PACKAGE

The training package includes the competencies chart, the flowchart, the modules, the course structure, and the assessment guidelines.

Course structure

The course structure describes the learning outcomes for each learning unit. These learning outcomes are the essential skills and knowledge to be acquired. The contents to be covered for each learning outcome are prescriptive. The Learning activities contain a series of suggestions, usually with several options, that will guide the learner and the trainer.

Flowchart

The flowchart of sequencing of learning is a schematic representation of the order of acquisition of the competencies. It provides an overall planning of the entire training programme and shows the relationship between the modules. This type of planning is to ensure consistency and progression of learning. For each module, the flowchart shows the learning that is already in place, the learning that is to take in parallel or later. The positions defined will have a decisive impact on all subsequent pedagogical choices. The flowchart of the sequence of learning of the modules of the training programme is presented on the following page.

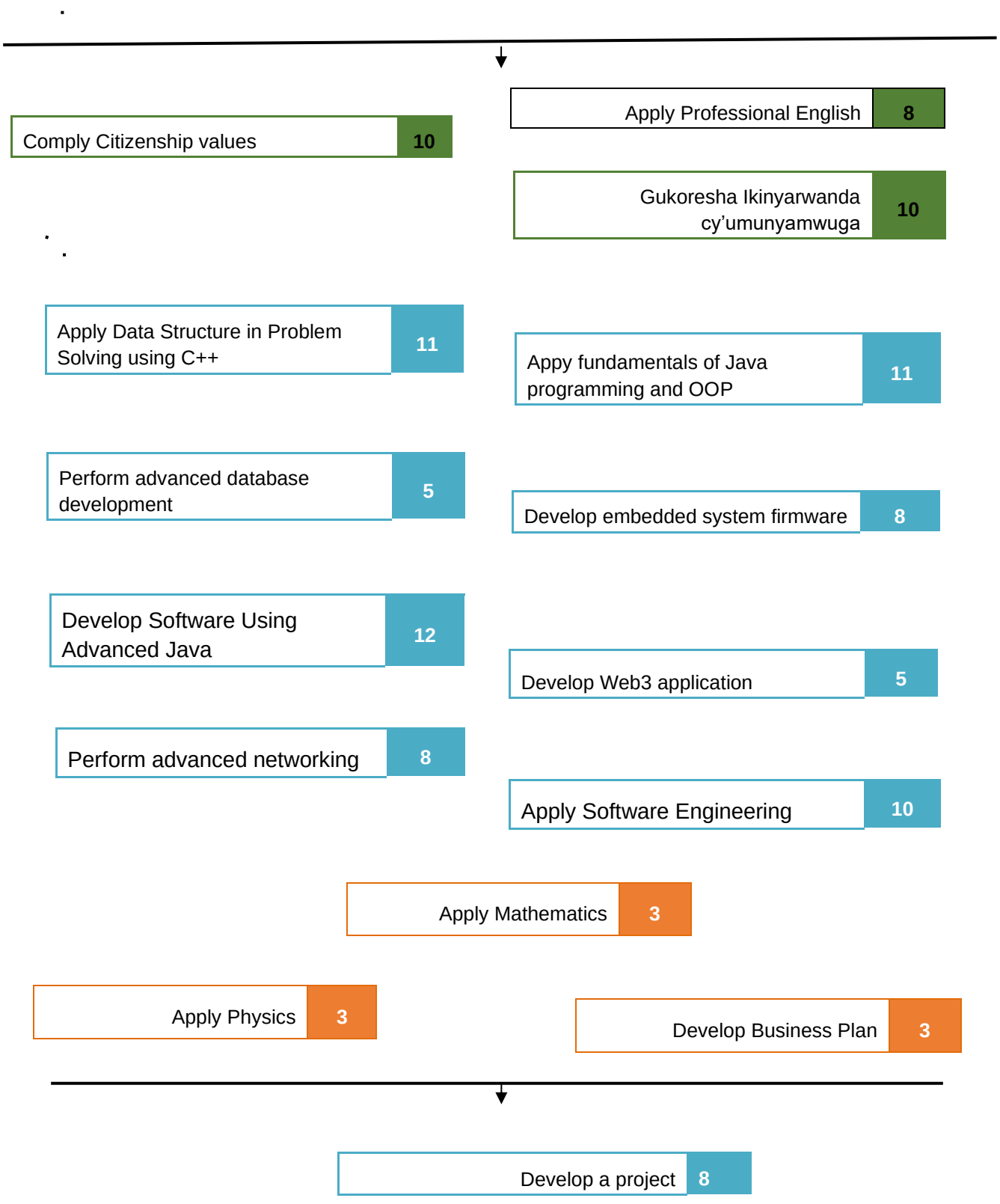

Figure 1: *Flowchart*

ASSESSMENT GUIDELINES

Assessment Methodology

To assess knowledge, practical, and application skills through a jury system of continuous evaluation that encourages learners to display understanding of the principles in application to set practical tasks and their attendant theory to assess self-learning.

There are two types of assessment (Formative Assessment and Summative/Integrated Assessment). Each assessment has its own rule for passing to be declared competent.

Formative Assessment

This is applied on all types of modules (e.g., Complementary, General and Specific modules).

A trainee to be competent for a formative assessment of a module must have at least 70%.

A trainee to be eligible to undertake integrated assessment of specific modules must have at least 50% as passing line for general and complementary modules.

Each trainee should be competent on all formative assessments to be declared competent on that module.

All formative assessment should be declared competent before taking the summative/integrated assessment.

Summative Assessment

All Summative/Integrated assessment should match with the content of the module in the curriculum.
Summative/Integrated Assessment is always practical, giving it as a theoretical type of assessment is not acceptable.
The integrated situation provided in the curriculum is a sample of the assessment to be carried out, the Trainer/Teacher has the role of developing another one referring to the task to be carried out in the integrated situation in accordance to the circumstances inside school, but the integrated situation should stick to the components of a task.
During Summative/Integrated assessment, assessor panel members should be three (3).

The trainee can be declared competent based on the assessment criteria and its respective assessment indicators.

The Passing Line for the modules is:

- 50 % for general and complementary modules
- 70 % for specific modules

<table>
<tr><th colspan="2">Training delivery</th><th>100%</th><th colspan="2">Assessment</th><th>Total 100%</th></tr>
<tr><td colspan="2">Theoretical content</td><td>30%</td><td rowspan="4">Formative assessment</td><td>30%</td><td rowspan="4">50%</td></tr>
<tr><td colspan="2">Practical work:</td><td rowspan="3">70%</td><td rowspan="3">70%</td></tr>
<tr><td>Group project and presentation</td><td>30%</td></tr>
<tr><td>Individual project /Work</td><td>40%</td></tr>
<tr><td colspan="2"></td><td colspan="2">Summative Assessment</td><td>50%</td></tr>
</table>

Note: Summative assessment is always conducted at the completion of module delivery. It should be practical through an integrated situation for specific modules and in any other forms of assessment for complementary and general modules.

GLOSSARY

Assessment: A process of gathering and judging evidence in order to decide whether a person has attained a standard of performance.

Assessment criteria: Statements which describe performances and place them in context with sufficient precision to allow valid and reliable assessment.

Best practice: Management practices and work processes that lead to outstanding or top-class performance and provide examples for others.

Competency standard: An industry-determined specification of performance which sets out the skills, knowledge and attitudes required to operate effectively in employment. Competency standards are made up of units of competency, which are themselves made up of elements of competency, together with performance criteria, a range of variables, and an evidence guide.

Competency: means the ability to apply knowledge, skills and personal, social and methodological skills in the workplace or during learning, as well as in personal and professional development. This ability or capacity is acquired through learning, exposure to the tasks and series of training allowing one to perform specific tasks autonomously. Reason why in the context of the CBE Framework competencies are described as responsibility and independence.

Competency-based assessment (or CBA): The gathering and judging of evidence in order to decide whether a person has achieved a standard of competency.

Complementary competencies: Set of knowledge, skills and attitudes which are not directly linked to a specific occupation or industry, but which are important for work, education and life in general, such as communication, mathematics, organizational aptitude, and computer literacy, interpersonal and analytical competency.

Core modules: Modules leading to competencies' acquisition that an industry sector has agreed upon as essential for a person to be accepted as competent at a particular level. All modules may be core, but in many cases competency at a level will involve core modules plus optional or specialization modules. Core competencies are normally those central to work in a particular industry.

Credential: Formal certification issued for successful achievement of a defined set of outcomes, e.g. successful completion of a course in recognition of having achieved particular knowledge, skills or competencies; successful completion of an apprenticeship or traineeship.

Credit: The acknowledgement that a person has satisfied the requirements of a module.
Curriculum: The specifications for a course or subject (module) which describe all the learning experiences a learner undergoes, generally including objectives, content, intended learning outcomes, teaching methodology, recommended or prescribed assessment tasks, assessment examples, etc.

Evidence guide: The part of a competency standard which provides a guide to the interpretation and assessment of the unit of competency, including the aspects which need to be emphasized in assessment, **relationships to other units, and the required evidence of competency.**
Flexible delivery: A range of approaches to providing education and training, giving learners greater choice of when, where and how they learn. Flexible delivery may involve distance education, mixed-mode delivery, online education, self-paced learning, self-directed learning, etc.

Formal education: Also, formal training education or training provided in educational institutions such as schools, universities, colleges, etc. or off the job in a workplace, usually involving direction from a teacher or instructor.

General competencies: competencies correspond to larger operations that go beyond the tasks, but generally contribute to their implementation. These activities require more fundamental learning and are generally common to several tasks and transferable to many work situations.

Generic modules: Modules leading to the attainment of complementary competencies.
Informal education: The acquisition of knowledge and skills through experience, reading, social contact, etc.
Internship: An opportunity for a learner to integrate career related experience by participating in planned, supervised work.
Key competencies: Any of several generic skills or competencies considered essential for people to participate effectively in the workforce. Key competencies apply to work generally, rather than being specific to work in a particular occupation or industry. The following are key areas of competency which were developed into seven key competencies: collecting, analysing and organizing information; communicating ideas and information; planning and organizing activities; working with others and in teams; using mathematical ideas and techniques; solving problems; and using technology.
Knowledge: means the result of the adoption of information through the learning process. Knowledge is a set of facts, principles, theories and practices related to the area of work or study. In CBE context lifelong learning knowledge is described as theoretical and / or factual.

Learning outcomes: are statements of what the learner knows, understands and can perform, based on the completion of the learning process, defined by knowledge, skill and competency.
Learning activities: Suggested activities that can be developed during lesson planning and activity preparation. The choice of learning activities must be tailored according to group size, available material resources and communication tools.
Learning hours: Number of hours required to acquire the competency, including the time allocated to evaluation, which is estimated between 5 and 10% of the total learning time of the competency.
Learning outcomes: Statements that indicate what learners will know or be able to do as a result of a learning activity. Learning outcomes are usually expressed as knowledge, skills, or attitudes.
Learning unit: Any of the basic building blocks of a module, which describes the key activities or the elements of the work covered by the module
Module: A unit of training which corresponds to one competency and which can be completed on its own or linked to others.
Occupation: The principal business of one's life.

Performance criteria: the part of a competency standard specifying the required level of performance in terms of a set of outcomes which need to be achieved in order to be deemed competent. It describes the quality requirements of the result obtained in labor performance.

Qualification: means the formal name for the result of a process of assessment and validation, which is obtained when a competent body determines that an individual has achieved learning outcomes to the standards laid down.

Quality assurance: The systems and procedures designed and implemented by an organization to ensure that its products and services are of a consistent standard and are being continuously improved.

Recognition of prior learning (or RPL): The acknowledgement of a person's skills and knowledge acquired through previous training, work or life experience, which may be used to grant status or credit in a subject or module.

Skills: are the ability to apply knowledge and use the principle of "know how" to perform a specific task and to solve the problem. In the context of the CBE Framework, skills are defined as cognitive (involving the use of logical, intuitive and creative thinking), practical (including physical skill and use of methods, materials, devices and instruments) and social skills (communication and cooperation skills, emotional intelligence and other).

Specific competencies: Competencies that are directly related to the tasks of the occupation in the workplace context. They refer to concrete, practical, and focused aspects

Traineeship: A system of vocational training combining off-the-job training at an approved training provider with on-the-job training and practical work experience. Traineeships generally take one to two years and are now a part of the New Apprenticeships system.

Unit of competency: A component of a competency standard. A unit of competency is a statement of a key function or role in a particular job or occupation. See also element of competency, performance criteria, range of variable