NATIONAL COMPETENCY STANDARDS
FOR
ROBOTICS TECHNICIAN
(CERTIFICATE 3)

ICT

TECHNICAL & VOCATIONAL EDUCATION AND TRAINING QUALITY COUNCIL
BHUTAN QUALIFICATIONS AND PROFESSIONALS CERTIFICATION AUTHORITY
THIMPHU, BHUTAN
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FOREWORD

The TVET Quality Council, BQPCA, is pleased to present the National Competency Standards (NCS) for Robotics Technician, Certificate 3, developed in collaboration with industry experts and trainers. These standards establish a nationally recognized qualification aligned with international best practices, setting a benchmark for TVET qualifications in Bhutan.

The NCS ensures that trainees acquire the necessary skills, knowledge, and attitude required by industries. Developed through close consultation with experts, it enhances the relevance of training to labor market needs, equipping graduates to meet industry expectations and improving their employability. A strong and responsive TVET system will also make vocational education more attractive to youth.

The Council acknowledges the valuable contributions of industry experts and trainers in the development of these standards. We urge employers and training providers to continue their support in implementing the NCS, fostering a skilled and productive workforce that contributes to national socio-economic development. Moving forward, we look forward to enhanced industry engagement and collaborative efforts in building a quality-assured, demand-driven TVET system.

Director
BQPCA

ACKNOWLEDGEMENT

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Next date of Revision : 16 July 2030

The TVET Quality Council, BQPCA would like to express our deepest appreciation to the following industry and subject matter experts who have participated in development of the National Competency Standards:

Experts Involved in development of the NCS			
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Experts involved in validation of the NCS			
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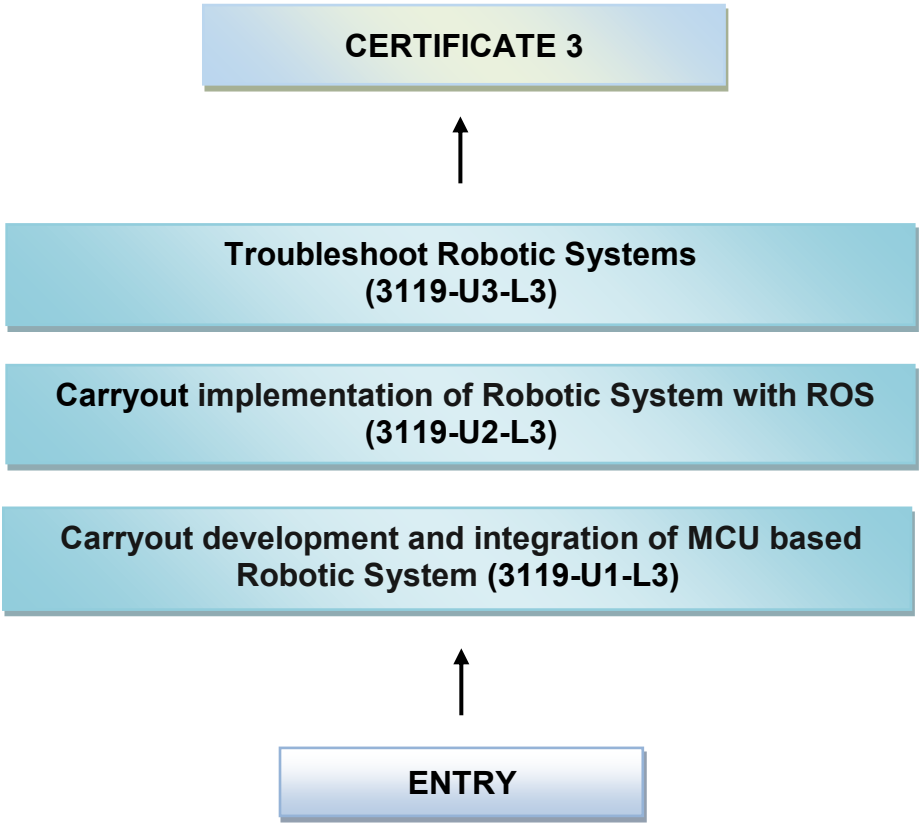
PACKAGING OF QUALIFICATIONS



OVERVIEW OF THE NCS

Unit Title	Element of Competence
1. Carryout development and integration of MCU based robotic system	1. Install Operating system and application Software 2. Program microcontroller to communicate with robotic components 3. Design mobile robotics components 4. Develop motion programs using microcontroller
2. Carryout implementation of Robotic system with ROS	1. Install Operating System and Application Software on the Single Board Computer (SBC) 2. Program microcontroller and SBC to communicate with one another 3. Program SBC to use ROS2 and sensors 4. Interface SBC hardware to ROS2 framework 5. Program a Robot using SBC-microcontroller and ROS2
3. Troubleshoot Robotic Systems	1. Troubleshoot malfunctions 2. Debug Robotic scripts 3. Perform maintenance of Robotic system

UNIT TITLE	Carryout development and integration of MCU based Robotic System
DESCRIPTOR	This unit contains competencies required to develop, integrate, and test a robotic system by programming a Microcontroller Unit (MCU).
CODE	3119-U1-L3
ELEMENTS OF COMPETENCE	**PERFORMANCE CRITERIA**
1. Install Operating system and application Software	1.1. Select and use ***PPEs*** as per the job requirement 1.2. Select ***Tools and Equipment*** as per the job requirement 1.3. Install Ubuntu on computer 1.4. Configure required software using command line tool 1.5. Store code in collaborative version control platform 1.6. Install microcontroller libraries
2. Program microcontroller to communicate with robotic components	2.1. Create programs for ***Input devices*** to communicate with microcontroller 2.2. Create programs for ***Output devices*** to communicate with microcontroller 2.3. Use simulation software to simulate ***Input Output devices*** to communicate with microcontroller.

3. Design mobile robotics components	3.1. Install designing software 3.2. Create 2D sketch 3.3. Design 3D model 3.4. Assemble 3D models
4. Develop motion programs using microcontroller	4.1. Develop an open loop motion program 4.2. Develop a closed loop motion program 4.3. Develop a Program to drive on a test track with multiple sensors

RANGE STATEMENT	
PPEs may include but not limited to:	
• Safety boot • Hand gloves • Face Masks	• Goggles • Work dress
Tools and Equipment may include but not limited to:	
• Screwdriver set • Multimeter • Hot Air Gun • Tweezer	• Soldering Kit • Long Nose Plier • Wire Stripper • Laptop
Input Output Devices may include but not limited to:	
• LED • Motor • Sensors	• Buzzer • LCD

Critical Aspects
• Follow safety practices at workplace • Follow standard procedure for all the tasks • Generate 3D model • Secure wiring and connections • Program Sensors and Actuators

UNDERPINNING KNOWLEDGE	UNDERPINNING SKILLS
• Ethics and Integrity • Occupational Health and Safety regulations • Basic first Aid • Basic Robotic Design • Basic mechanical systems (gears, levers, fasteners) • Basic electrical and electronics • Electrical and electronic components • Reading and interpreting technical drawings and wiring diagrams • Communication protocols • Programming logic, variables, loops and conditions • Basics of embedded systems and real-time operation • Types of Robotic controllers	• Team Work • Communication • Problem Solving • Interpersonal Relationship • Time Management • Innovation

UNIT TITLE	Carryout implementation of Robotic System with ROS
DESCRIPTOR	This unit contains competencies required to develop and integrate robotic software applications using the ROS framework.
CODE	3119-U2-L3
ELEMENTS OF COMPETENCE	**PERFORMANCE CRITERIA**
1. Install Operating System and Application Software on the Single Board Computer (SBC)	1.1 Install Ubuntu on SBC 1.2 Configure required software using command line tool 1.3 Configure communication network between PC and SBC
2. Program microcontroller and SBC to communicate with one another	2.1 Create a communication program over serial 2.2 Create a communication program over SPI 2.3 Create a communication program over i2c
3. Program SBC to use ROS2 and sensors	3.1 Install ROS2 3.2 Echo a topic from ROS2 3.3 Publish a topic in ROS2 3.4 Visualize topics using simulation tools 3.5 Plot a Lidar point cloud with ROS2 3.6 Plot a Depth Camera image with ROS2
4. Interface SBC hardware to ROS2 framework	4.1 Maneuver robot with ros2_control 4.2 Publish Ultrasonic data with ros2_control 4.3 Publish IMU data with ros2_control

	4.4 Publish Lidar data with ros2_control 4.5 Publish Depth Camera image data with ros2_control
5. Program a robot using SBC - microcontroller and ROS2	5.1 Implement a motion program using motor encoders 5.2 Implement sensor fusion between motor encoders and IMU 5.3 Implement robot control remotely using teleop_twist_joy 5.4 Implement a motion program for localization with Lidar (SLAM)

RANGE STATEMENT
Critical Aspects
• Follow safety practices at workplace • Follow standard procedure for all the tasks • Configure communication network between PC and SBC

UNDERPINNING KNOWLEDGE	**UNDERPINNING SKILLS**
• Ethics and Integrity • OHS Regulations • Basic first Aid • Sensor data types and interpretation • Control algorithms • Communication protocols • ROS / SLAM	• Team Work • Communication • Problem Solving • Interpersonal Relationship • Time Management • Innovation

UNIT TITLE	Troubleshoot Robotic Systems
DESCRIPTOR	This unit contains competencies required to troubleshoot mobile robotic systems following standard procedure.
CODE	3119-U3-L3
ELEMENTS OF COMPETENCE	PERFORMANCE CRITERIA
1. Troubleshoot Malfunctions	1.1 Select and use ***PPEs*** as per the job requirement following standard procedure. 1.2 Select ***Tools and Equipment*** as per the job requirement following standard procedure. 1.3 Select ***Materials*** as per the job requirement following standard procedure. 1.4 Perform physical inspection 1.5 Troubleshoot electrical faults 1.6 Troubleshoot mechanical faults
2. Debug Robotics Scripts	2.1 Analyze Control Flow of Robotic Script 2.2 Monitor variable values and states 2.3 Interpret Sensor and Actuator Data 2.4 Rectify errors in Robotics Scripts
3. Perform maintenance of robotic system	3.1 Perform scheduled maintenance of Robotic system components 3.2 Update software and firmware as required 3.3 Maintain logs and documentation.

RANGE STATEMENT	
PPEs may include but not limited to:	
• Safety boot • Hand gloves • Face Mask	• Goggles • Work dress • Rubber Mat
Tools and Equipment may include but not limited to:	
• Screw Driver Set • Multimeter • Hot Air Gun • Wire Stripper	• Laptop • Soldering Kit • Drill set
Materials may include but not limited to:	
• Soldering wire • Flux • Insulation tape	• Heat shrink tube • Nuts and bolts
Critical Aspects	
• Follow safety practices at workplace • Follow standard procedure for all the tasks • Detect faults • Rectify errors in Robotics Scripts	

UNDERPINNING KNOWLEDGE	UNDERPINNING SKILLS
• Ethics and Integrity • Occupational Health and Safety regulations • Basic first Aid • Programming logic, variables, loops, and conditions • Sensor data types and interpretation • Control algorithms • Basics of embedded systems and real-time operation • Communication protocols • Basics of electrical and electronics • Types of maintenance • Failure root cause analysis	• Team Work • Communication • Problem Solving • Interpersonal Relationship • Time Management • Innovation

ANNEXURE

National Competency Standards (NCS)

The National Competency Standards specify the skill, knowledge and attitudes applied to a particular occupation. Standards also specify the standards or criteria of performance of a competent worker and the various contexts in which work may take place. Standards provide explicit advice to assessors regarding the skill and knowledge to be demonstrated by candidates seeking formal recognition either following training or through work experience.

Purpose of National Competency Standards

National Competency Standards serve a number of purposes including:

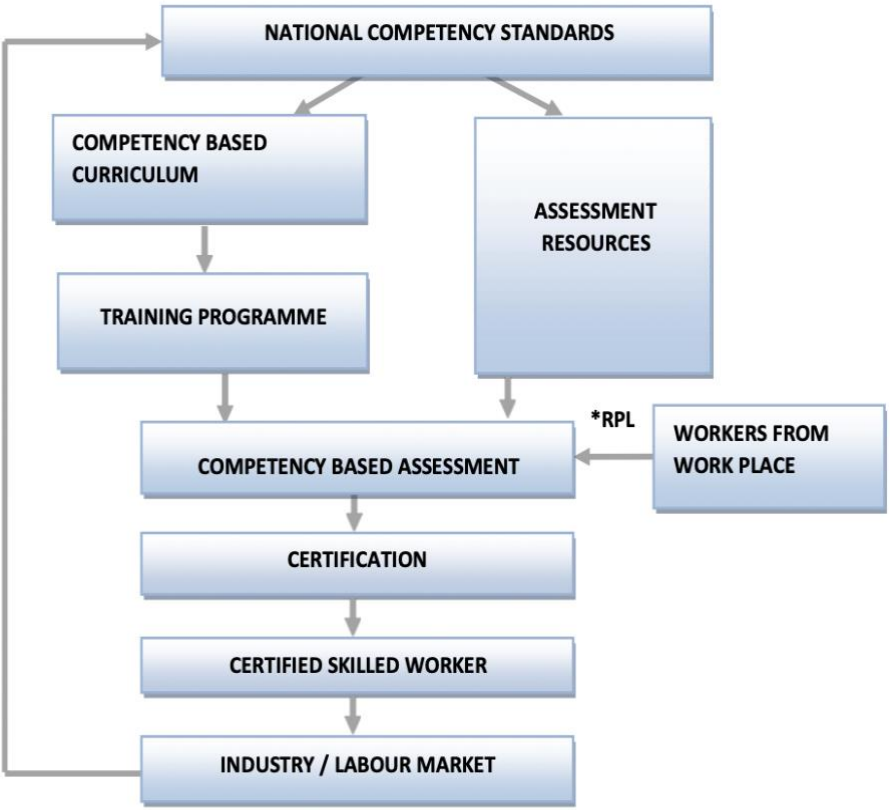
- Providing advice to curriculum developers about the competencies to be included in the curriculum.
- Providing specifications to assessment resource developers about the competencies within an occupation to be demonstrated by candidates.
- Providing advice to industry/employers about job functions, which in turn can be used for the development of job descriptions, performance appraisal systems and work flow analysis.

Bhutan Qualifications Framework (BQF)

Bhutan Qualifications Framework is an integrated national framework that outlines all types of qualification in Bhutan. As an established and nationally accepted instrument, the BQF has been benchmarked against international practices in terms of standards. The BQF aims to recognize all forms of learning systems, including formal, non-formal, and informal learning. It acknowledges technological advancements and recognizes contemporary

modes of delivery. It covers a broad range of education systems including the TVET education.

Implementation of TVET Qualifications



*** RPL = Recognition of Prior Learning**

TVET Qualifications Levels

TVET Qualifications have seven levels as per the BQF as follows:

Bhutan Qualifications Framework 2023

Table 2: Qualification Types and Levels Based on Education Sector.

BQF Level	Community Education	School Education	TVET	Higher Education	Monastic Education
8				Doctoral Degree	*Khewang* ཟབ་བསྟན་དབང་།
7			Master's Degree Postgraduate Diploma Postgraduate Certificate	Master's Degree Postgraduate Diploma Postgraduate Certificate	*Tsugla Gongma* གཙུག་ལག་གོང་མ།
6			Applied Degree	Bachelor's Degree Bachelor's Degree (Honours) Graduate Diploma Graduate Certificate	*Tsugla Wogma* གཙུག་ལག་འོག་མ།
5			Advanced Diploma	Advanced Diploma	
4			Diploma	Diploma	
3		Bhutan Higher Secondary Education Certificate	Certificate 3		*Dringrim Gongma* འབྲིང་རིམ་གོང་མ།
2		Bhutan Certificate for Secondary Education	Certificate 2		*Dringrim Barma* འབྲིང་རིམ་བར་མ།
1	ALC		Certificate 1		

Level Descriptors

The TVET Qualification levels are set based on the level descriptors, as defined in the BQF. The detail of the qualification level descriptor is as follow:

Level	Knowledge Knowledge that is:	Skills Demonstrate skills that involve:	Values Demonstrate values that involve:	Application Applied in contexts that involve:
4	Broad theoretical, technical and operational	Selecting and applying a range of standard processes relevant to varied and sometimes unpredictable tasks Selecting and applying a range of solutions involving formulation of solutions to resolve complex issues Demonstrating a high level of proficiency in English and Dzongkha	Strong level of awareness of self and others; and an appreciation of belief system, role of social norms, and the importance of relationship building Application of ethical norms and legal rules in decision-making; and comprehending the correlation between values and behavior Commitment to own profession and quality of work	Stable tasks with predictable changes Broad guidance with some self-direction that requires sound judgement Taking some responsibility for planning and coordination with others
3	Theoretical with some technical and operational processes	Applying a range of standard processes to known but varied tasks	Sound level of self-awareness and beliefs; and ability to	Stable tasks with some aspects of change

		Selecting and applying a range of solutions to familiar and unfamiliar problems Communicating effectively and clearly, both oral and written, in both English and Dzongkha	apply social norms and build relationships Application of a set of ethical norms Commitment to own field of interest and apply self-management of learning and performance	General guidance and supervision that require discretion and judgement Adapting to own behaviour to work with others
2	Basic, factual and conceptual	Applying standard processes relevant to carry out known tasks Applying a set of known solutions to solve simple and straightforward issues Using simple and direct exchange of information on familiar and routine matters Developing basic proficiency in Dzongkha and English	Some level of self-awareness and beliefs, and appreciation of social norms; and significance of relationships Awareness of ethical norms, and openness to different activities Developing own knowledge and skills	Structured and stable tasks General support and Supervision that require some discretion and judgement Collaboration with others to achieve goals
1	Foundational, every day and general	Applying operational literacy, numeracy skills required to carry out simple tasks Applying simple solutions to solve simple and	Basic awareness of self, beliefs, and social norms; and understand the significance of relationships	Highly structured tasks with close support and supervision Minimal Discretion and

		straightforward everyday issues Communicating using everyday expressions and simple phrases in Dzongkha and English	Basic awareness of fundamental ethical norms, basic civil rights, and responsibilities Willingness to understand tasks and motivated to implement them successfully	judgement Readiness to work together and share knowledge with others

CODING USED FOR NATIONAL COMPETENCY STANDARDS

The coding and classification system developed in Bhutan is logical, easy to use, and also aligned with international best practices. The Bhutanese coding and classification system is based on the International Standard Classification of Occupations, 2008 (ISCO-08) developed by the International Labour Organisation (ILO).The coding of the National competency standards forms the basis of the identification code for the Technical & Vocational Education and Training Management Information System (TVET – MIS) both in terms of economic sector identification and that of the individual standard.

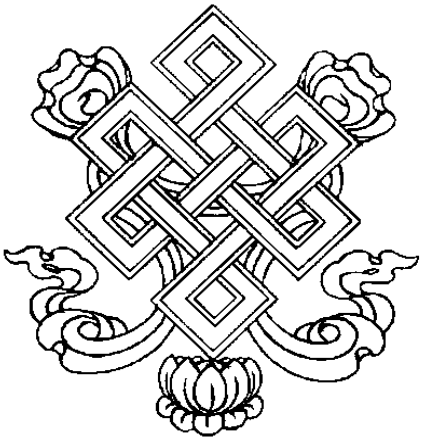
Coding the individual national competency standards

Coding the individual skills standard has a multiple purpose:

- to identify the level,
- to identify to which module the standard belongs,
- to identify in which order the standard is clustered within that module.

A job can include a number of competencies described in the national competency standards.

However, in order to follow a logical order, only national competency standards related to each other and following a logical sequence in terms of training delivery, from the simple to the complex, are clustered into a module. Some standards are so complex that they need to stand alone.



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