Next Generation Higher National Unit Specification

Machine Learning (SCQF level 9)

Unit code: J6CP 49

SCQF level: 9 (16 SCQF credit points)

Valid from: session 2023–24

Prototype unit specification for use in pilot delivery only (version 1.0) September 2023

This unit specification provides detailed information about the unit to ensure consistent and transparent assessment year on year.

This unit specification is for teachers and lecturers and contains all the mandatory information required to deliver and assess the unit.

This edition: September 2023 (version 1.0)

Unit purpose

This specialist unit is for learners who want to understand and apply the concepts, principles and technologies around machine learning. It is suitable for those with an interest in artificial intelligence (AI), computer science, data science or statistics.

Learners should be familiar with basic concepts in maths, and have experience of using a programming language such as Python or R. Previous experience of working with large datasets is assumed. We recommend that learners complete the Machine Learning unit at SCQF level 7 or the Machine Learning unit at SCQF level 8 before doing this unit.

It covers the basics of:

- machine learning concepts
- machine learning models
- the application of machine learning in various real-life situations and potential scenarios
- the most effective machine learning techniques and experience in applying them
- best practices in machine learning
- the innovation process in machine learning and AI
- ethics and regulations around machine learning and AI solutions

Learners explore contemporary developments in machine learning, such as deep learning, and the implications of the technology for business, science and society.

On completing this unit, learners understand the rationale for machine learning as a powerful method for data analysis, and appreciate the applications of the technology in a variety of vocational fields.

Unit outcomes

Learners who complete this unit can:

1 explain concepts in machine learning
2 describe machine learning methods and algorithms
3 explain deep learning concepts and its applications for individuals and society
4 explain machine learning model best practices, maintenance and governance

Evidence requirements

Learners must provide knowledge evidence.

Knowledge evidence

Evidence is required for all outcomes, however, the amount can be the minimum required to infer competence. Learners can produce evidence over an extended period of time, in lightly controlled conditions.

Evidence can be sampled when testing is used. In this case, learners must produce evidence under controlled conditions in terms of location (supervised), timing (limited) and access to reference materials (not allowed). Sampling must cover all four outcomes, but does not need to cover all knowledge and skills statements, as these can be lightly sampled in some instances. The sample must include:

- the machine learning process
- machine learning methods and algorithms
- the ethical implications of machine learning

Evidence produced under lightly-controlled conditions, must be authenticated. The Guide to Assessment provides further advice on methods of authentication.

The standard of evidence should be consistent with the SCQF level of this unit.

You should use appropriate level descriptors when making judgements about the evidence.

Knowledge and skills

The following table shows the knowledge and skills covered by the unit outcomes.

Knowledge	Skills
Learners should understand: ♦ the historical development of machine learning and its relationship to other fields within computer science ♦ the difference between traditional programming and machine learning ♦ computational learning theory and statistical learning theory ♦ the machine learning process ♦ machine learning models including decision trees, regression analysis and Bayesian networks ♦ data in machine learning models ♦ machine learning methods (supervised learning, unsupervised learning and reinforcement learning) ♦ machine learning algorithms (classification algorithms, regression algorithms and clustering algorithms) ♦ the historical development of deep learning and reasons for its growth ♦ artificial neural networks ♦ representation learning ♦ universal approximation theorem and probabilistic inference ♦ deep learning models ♦ the applications of deep learning for individuals and society ♦ the technologies used for implementing machine learning models ♦ the best practices in machine learning including bias and variance ♦ model maintenance ♦ model governance ♦ the ethical implications of machine learning and deep learning	Learners can: ♦ use technologies such as Python, MATLAB and R ♦ use deep learning in various machine learning solutions ♦ show computational thinking ♦ show critical thinking

Meta-skills

Throughout the unit, learners develop meta-skills to enhance their employability in the data science sector.

Self-management

This meta-skill includes:

- focusing: sorting, attention, filtering
- adapting: openness, critical reflection, adaptability, self-learning
- initiative: independent thinking, decision making

Social intelligence

This meta-skill includes:

- communicating: receiving information, giving information, storytelling
- feeling: social conscience

Innovation

This meta-skill includes:

- curiosity: observation, questioning, information sourcing, problem recognition
- creativity: idea generation, visualising, maker mentality
- sense-making: pattern recognition, holistic thinking, synthesis, opportunity recognition, analysis
- critical thinking: deconstruction, logical thinking, judgement, computational thinking

Literacies

Throughout this unit, learners have opportunities to develop their literacy skills.

Numeracy

Learners develop numeracy skills by working with large datasets.

Communication

Learners can develop writing communication skills if they use a blog to record evidence throughout the unit.

Digital

Learners develop digital skills and computer literacy throughout this unit.

Delivery of unit

If you deliver this unit as part of a group award, we recommend that you teach and assess it in the subject area of that group award.

Approaches to delivering this unit can include team working, pair programming, presentations, and research findings.

You must teach all of the content listed in the 'Knowledge and skills' section, even if you assess evidence for outcomes on a sample basis. Learners should know in advance the items being assessed, and you should sample different items on each assessment occasion.

While the exact time allocated to this unit is at your centre's discretion, the notional design length is 80 hours.

We suggest the following distribution of time:

Outcome 1 — Explain concepts in machine learning
(15 hours)

Outcome 2 — Describe machine learning methods and algorithms
(20 hours)

Outcome 3 — Explain deep learning concepts and its applications for individuals and society
(20 hours)

Outcome 4 — Explain machine learning model best practices, maintenance and governance
(25 hours)

Additional guidance

The guidance in this section is not mandatory.

Content and context for this unit

Learners gain an understanding of machine learning core concepts, the main models (supervised, unsupervised and reinforcement learning) and algorithms (classification, regression and clustering). They learn how to apply these concepts to the design and development of machine learning models. Learners also increase their knowledge of developing models and algorithms in their chosen technology (programming environment and various machine learning programming packages).

Learners can understand concepts around deep learning, such as computer vision and natural language processing (NLP) and explore the various applications of deep learning for individuals and society.

Additionally, learners receive guidance on best practices in machine learning, model maintenance and its types, together with model governance and its features required for an optimum machine learning model. This includes an understanding of current regulations and policies, and the legal and ethical implications of machine learning and deep learning.

Explain concepts in machine learning (outcome 1)

This covers the core concepts of machine learning. Learners explore the historical development of machine learning and its relationship to other fields within computer science. They gain an understanding of the differences between traditional programming techniques (such as Python, R, MATLAB and machine learning libraries) and machine learning. Learners understand data in machine learning modelling (including identification of variables, feature selection, labelling, data cleaning and transformation). Common technologies used in implementing machine learning models, and key elements to consider in modelling are:

- knowledge representation and formats (such as decision trees, graphical models, support vector machines and neural networks)
- model evaluation techniques (such as squared error, accuracy rate, cost and margin)
- model optimisation techniques (such as mini-batch gradient and stochastic gradient descent)

Describe machine learning methods and algorithms (outcome 2)

The focus is to provide a broad overview of the main methods and algorithms that learners use to develop a machine learning solution for a dataset, including:

- machine learning methods:
  - supervised learning
  - unsupervised learning
  - reinforcement learning

- machine learning algorithms:
  - classification algorithms
  - regression algorithms
  - clustering algorithms

You should organise practical activities as part of this outcome, using technologies such as Python, MATLAB and R.

Explain deep learning concepts and its applications for individuals and society (outcome 3)

The focus here is to provide an understanding of deep learning concepts and its models, including:

- artificial neural networks
- representation learning
- universal approximation theorem and probabilistic inference

Learners should explore the historical development of deep learning and the different reasons for its growth, and learn about how to use deep learning in various machine learning solutions, such as:

- computer vision
- speech and audio recognition
- NLP
- medical computing (bioinformatics, drug design, and medical image analysis)
- finance systems
- services recommendations
- social network filtering
- machine translation
- material inspection
- board game programs

You should ensure learners understand the machine learning solutions' relationship to the methods and algorithms covered in outcome 2.

This outcome includes a number of practical activities, using technologies such as Python (with Scikit-learn, OpenCV, Octave), MATLAB (with ML Toolbox) and R (with caret, tree, e1071). Learners should also understand popular ML cloud workbenches, such as Google Machine Learning workbench (TensorFlow), Microsoft Azure ML Studio, Amazon ML SageMaker and IBM Watson Studio.

Explain machine learning model best practices, maintenance and governance (outcome 4)

This builds on knowledge of machine learning model best practices (bias and variance). It focuses around the design and implementation of machine learning models and model maintenance, including:

- corrective maintenance (fixing detected data and algorithm issues)
- adaptive maintenance (enabling model to run in various environments)
- perfective maintenance (updating model and adding new features or concepts)
- preventive maintenance (implementing changes to prevent model errors)

It also builds on knowledge of model governance practices, such as:

- data usage and governance
- model validation and verification
- model risks and security
- model testing (operational and performance)
- preventive controls (including human intervention)
- rules, ethics and regulations compliance
- model deployment
- model performance monitoring
- model calibration and adjustment

When covering the ethical implications of machine learning and deep learning, you should explore various initiatives. Examples include AI for Good (A Move Towards Ethical AI); Google and Microsoft AI principles campaigns; UK and European governments' initiatives towards a safe and regulated AI industry. In addition, privacy and use of data (such as General Data Protection Regulation (GDPR)) and the importance of using the right motivations and design principles in AI and machine learning solutions.

There is a growing trend of online resources for advanced machine learning topics. This includes completing online courses from providers such as Coursera, Udemy, Udacity, edX and FutureLearn; and extensive learning materials from machine learning workbench providers, such as Microsoft, AWS, Google and Apple.

Useful online resources include:

- Data Science Solutions (OCI)
- Elite Data Science
- Machine Learning Mastery

Approaches to assessment

Evidence can be generated using different types of assessment. The following are suggestions, however, there may be other methods that could be more suitable for your learners.

One approach is a test. This could be an extended-response question paper, carried out in controlled conditions for a defined period of time. For example, a 2-hour test could have six questions covering all outcomes, each requiring an essay-type response. If each question is worth 10 marks, you could set a pass mark of 30 marks.

A more contemporary approach to assessment would be learners using a blog to record learning (and associated activities) throughout the unit. Blogs could provide the knowledge evidence (in the descriptions and explanations) of all the outcomes, and knowledge and skills statements. You should assess the blog using defined criteria to judge the quality of the digital evidence. In this approach to assessment, there must be evidence of every knowledge and skill — sampling is not sufficient.

You can use formative assessment to assess knowledge at various stages throughout the unit. An ideal time is at the end of each outcome. You can deliver the assessment through an item bank of selected-response questions, providing diagnostic feedback to learners (where appropriate).

If learners use a blog for summative assessment, it also helps formative assessment, as learning (including misconceptions) is apparent from the blog, and you can correct misunderstandings on an on-going basis.

You can carry out summative assessment at any time. However, when using testing (see the ‘Evidence requirements’ section) we recommend that you carry it out towards the end of the unit.

If you use continuous assessment (such as using a blog), you can start this early in the unit and continue throughout.

You have opportunities to carry out formative assessment at various stages in the unit. For example, on completing each outcome, to ensure that learners have grasped the knowledge contained within it. This provides you with an opportunity to diagnose misconceptions and intervene to remedy them before progressing to the next outcome.

Equality and inclusion

This unit is designed to be as fair and as accessible as possible with no unnecessary barriers to learning or assessment.

You should take into account the needs of individual learners when planning learning experiences, selecting assessment methods or considering alternative evidence.

Guidance on assessment arrangements for disabled learners and/or those with additional support needs is available on the assessment arrangements web page.

Information for learners

Machine Learning (SCQF level 9)

This information explains:

- what the unit is about
- what you should know or be able to do before you start
- what you need to do during the unit
- opportunities for further learning and employment

Unit information

This unit provides you with an understanding of the theory and practice of machine learning. It is for those who appreciate the importance of machine learning and want a better understanding of the fundamental concepts on which its application is based.

Before starting this unit, you should have previous knowledge and skills in applying statistical concepts to large datasets and be familiar with at least one high-level programming language such as Python or R. Previous knowledge of machine learning would be an advantage.

There are four outcomes. These develop your knowledge and understanding of the concepts and technologies around machine learning, along with some practical competence in using software tools that perform these technologies.

Some of the topics included are:

- the historical development of machine learning, and its relationship to other fields within computer science
- the difference between traditional programming and machine learning
- the machine learning process
- machine learning models, including decision trees, regression analysis and Bayesian networks
- data in machine learning models
- machine learning methods (supervised learning, unsupervised learning and reinforcement learning)
- machine learning algorithms (classification algorithms, regression algorithms and clustering algorithms)
- deep learning models
- best practices in machine learning including bias and variance
- ethical implications of machine learning and deep learning

You are assessed using a range of assessment methods, most of which are theory based, although you have opportunities throughout the unit to develop practical competencies.

You develop meta-skills in self-management, social intelligence and innovation.

On completing this unit, you will understand the rationale for machine learning as a powerful method for data analysis, and appreciate the applications of the technology in a variety of vocational fields.

Administrative information

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Superclass: CB

History of changes

Version	Description of change	Date

Note: please check SQA's website to ensure you are using the most up-to-date version of this document.