SQA Advanced Unit specification

General information

Unit title: Artificial Intelligence for Computer Games (SCQF level 8)

Unit code: HT00 48

Superclass: CB

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Version: 01

Unit purpose

This unit is designed to provide learners with knowledge and skills about Artificial Intelligence in general and to develop an understanding of how Artificial Intelligence (AI) techniques are used in computer games. The unit focuses on the principles of Artificial Intelligence and implementation of the techniques is not required. Working in teams, learners will be able to plan a strategy for implementing an intelligent component of a computer game and then they will be able to critically evaluate their plan.

This unit is intended for learners who are proposing to follow a career in the computer games industry.

Outcomes

On successful completion of the unit the learner will be able to:

1 Explain the principles of artificial intelligence techniques.
2 Explain artificial intelligence techniques for computer games.
3 Plan a strategy for implementing an intelligent component of a computer game.
4 Critically evaluate the plan.

Credit points and level

2 SQA Credits at SCQF level 8: (16 SCQF credit points at SCQF level 8)

Recommended entry to the unit

Access to this unit is at the discretion of the centre. However, it is recommended that learners have prior exposure to computer systems, and ideally some experience in using computer games. It would be advantageous for learners to have knowledge and understanding of game narrative and genre.

This may be demonstrated by the possession of relevant National units, SQA Advanced units or experience.

Core Skills

Achievement of this Unit gives automatic certification of the following Core Skills component:

Complete Core Skill None

Core Skill component Critical Thinking at SCQF level 6

There are also opportunities to develop aspects of Core Skills which are highlighted in the Support Notes of this Unit specification.

Context for delivery

If this unit is delivered as part of a Group Award, it is recommended that it should be taught and assessed within the subject area of the Group Award to which it contributes.

Equality and inclusion

This unit specification has been designed to ensure that there are no unnecessary barriers to learning or assessment. The individual needs of learners should be taken into account when planning learning experiences, selecting assessment methods or considering alternative evidence.

Further advice can be found on our website **www.sqa.org.uk/assessmentarrangements**.

Unit specification: Statement of standards

Unit title: Artificial Intelligence for Computer Games (SCQF level 8)

Acceptable performance in this unit will be the satisfactory achievement of the standards set out in this part of the unit specification. All sections of the statement of standards are mandatory and cannot be altered without reference to SQA.

Where evidence for Outcomes is assessed on a sample basis, the whole of the content listed in the Knowledge and/or Skills section must be taught and available for assessment. Learners should not know in advance the items on which they will be assessed and different items should be sampled on each assessment occasion.

Outcome 1

Explain the principles of artificial intelligence techniques.

Knowledge and/or Skills

- Machine learning
- Problem representation and search
- Artificial neural networks (ANN)
- Genetic algorithms
- Applications of artificial intelligence
- Impact of artificial intelligence on society

Outcome 2

Explain artificial intelligence techniques for computer games.

Knowledge and/or Skills

- History and development of Artificial Intelligence in computer games
- Finite State Machines
- Behaviour Trees
- Pathfinding
- Search algorithms
- AI Agents
- Case-Based Reasoning
- Evaluation functions
- AI cheating in games
- AI techniques used in specific games

Outcome 3

Plan a strategy for implementing an intelligent component of a computer game.

Knowledge and/or Skills

- Applying artificial intelligence techniques in the context of a computer game
- Analysis of a scenario and goals of the intelligent component
- Selection of suitable artificial intelligence techniques to achieve the goals of the intelligent component
- Identification of pertinent information from the scenario
- Role of logical relationships between components/entities
- Possible avenues of improvement

Outcome 4

Critically evaluate the plan.

Knowledge and/or Skills

- Critical evaluation of evidence
- Testing generalisations and assumptions
- Reaching conclusions

Evidence Requirements for this unit

Candidates will need to provide evidence to demonstrate their Knowledge and/or Skills across all Outcomes.

The evidence for this unit may be written or oral or a combination of these. Evidence may be captured, stored and presented in a range of media (including audio and video) and formats (analogue and digital). Particular consideration should be given to digital formats and the use of multimedia.

The Evidence Requirements for this unit will take **two** forms.

1 Evidence of cognitive competence (for Outcomes 1 and 2).
2 Evidence of practical competence (for Outcomes 3 and 4).

For the evidence of **cognitive competence** in Outcomes 1 and 2, candidates must demonstrate that they will be able to:

- explain what is meant by machine learning.
- describe how a problem can be broken into a searchable space.
- describe artificial intelligence techniques including ANN and Genetic algorithms.
- explain the applications of artificial intelligence in contexts such as consumer services and research.
- explain the impact that AI will have, or is having on society.
- explain the history and development of AI in games.
- describe the role of pathfinding in a computer game.
- describe the role of behaviour tree in a computer game
- describe the role and purpose of at least two search algorithms.

- explain the role of Intelligent Agents within a game.
- explain how case-based reasoning can be used in a game.
- explain the role of evaluation functions are used in games.
- explain how AI cheating is sometimes used to make game AI appear intelligent.
- demonstrate how AI techniques have been used in at least one game.

Sampling is permissible when the evidence for cognitive competence is produced by a test of knowledge and understanding. The test may take any form (including oral) but must be supervised, unseen and timed. The contents of the test must sample broadly and proportionately from the contents of the knowledge domain (see above). Access to reference material is not appropriate for this type of assessment.

Outcomes 3 and 4 are assessed together as a teamwork assignment based upon a brief. Candidates will work in teams to produce evidence in the form of a single portfolio of work for the team which will cover all of the Knowledge and Skills for both Outcomes.

The portfolio will consist of the following items collated by the team:

- An interpretative summary of the problem(s) given in the brief
- Aims or goals for the plan to solve the problem(s)
- Analysis of the facts and/or data presented in the brief which should include details of any assumptions or generalisations
- Details of the game's strategy in relation to its AI
- Planning documents which must include:
  - an outline of possible methods to be used to implement a component of AI
  - diagrams, flowcharts, or designs to demonstrate aspects of the plan or intelligent components
  - Pseudocode
  - notes from discussions or team blogs
  - any other relevant planning document assisting development of the knowledge or skills
- The plan
- A prototype or walkthrough showing how the intelligent component would react to specific situations that would arise. This will consist of either:
  - Animation, pseudo code or flowchart based walkthrough of the scenario and how the intelligent component would react; **OR**
  - A code-based prototype showing an implementation or realistic simulation of the AI techniques.
- Amendments to the plan based upon critical evaluation
- An evaluative summary of the effectiveness of the final strategy
- Log of team progress
- Any other appropriate piece of work that incorporates the Knowledge and Skills for this Outcome

In addition to the teamwork portfolio submission, individual evidence should also demonstrate the candidate's contribution to, and evaluation of, the final plan.

Individual evidence:

- Diary, blog or logbook containing comments, thoughts and reflections on progress
- Evidence of any information they have gathered to contribute to the team
- Evidence of any diagrams or charts they have assisted with to aid team decision making
- Notes that they have recognised any assumptions and discussed this with the team and have participated in testing these assumptions

Team evidence:

- Portfolio of work as detailed above
- Demonstrate that they have devised methods to solve the problem
- Gathered and interpreted data to enable informed choices for future action
- Prototype demonstrating how the intelligent component would use applicable AI techniques
- Progressively improve the desired Outcome of the situation or problem
- Test any generalisations and conclusions
- Justify the conclusion reached

Evidence of practical competence for Outcomes 3 and 4 may be produced over an extended period of time under open-book conditions; but where it is generated without supervision some means of authentication must be carried out.

The Guidelines on Approaches to Assessment (see the Support Notes section of this specification) provides specific examples of instruments of assessment.

Unit Support Notes

Unit title: Artificial Intelligence for Computer Games (SCQF level 8)

Unit Support Notes are offered as guidance and are not mandatory.

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

Guidance on the content and context for this unit

This unit has been developed to form part of the SQA Advanced Diploma in Computer Games Development and is suitable for learners who are proposing to follow a career in the games industry. It is anticipated that the unit would be delivered in the second year of the award if traditional delivery schedules are being observed.

Teamwork is an important aspect of learning in this unit since when trying to solve problems it is often better to discuss ideas and work things out collectively.

Outcome 1

This Outcome provides an opportunity for learners to understand AI techniques and how AI is applied to various domains in society. AI is an increasingly important tool for analysing data and creating systems that can recognise and classify inputs and then make decisions. There are some tools for machine learning under open licenses, allowing businesses and service providers to incorporate AI techniques into their offerings (for example, Tensorflow https://www.tensorflow.org/).

AI techniques are being used in a wide variety of contexts. Neural networks can be set up and trained to classify a wide range of inputs from finding objects in photographs or text. These tools are being used to develop services that are increasingly used in every day contexts. For example, Siri, Google Now and Cortana are artificial intelligence systems as personal assistants accessed through the mobile phone. AI systems have been demonstrated that can take part in TV quizzes and act as receptionists. Further development AI may lead to losses in job sectors where decision making could be taken over by an AI system capable of evaluating the factors involved. Systems such as this are starting to have an impact on everyday life.

Learner should be able to explain how problems can be broken into a set of searchable possible solutions or 'states'. The problem solving process searches the possible states until it reaches the goal state, which is the desired solution. Chess is a classic example of this type of AI problem solving. When looking at the board, the AI searches through all of the possible legal moves until it finds one that would provide the best position. The disadvantage of this is that there are a very large number of possible moves in chess and therefore evaluating and finding a good move involves searching through a large number of possible moves, so the process of finding a good move can be time consuming.

The Artificial Neural Network is a technique that is modelled on the principles used by biological neural networks. Neural networks are applied to tasks that can be learned — as the process of iteratively analysing input and updating the network leads to better recognition or classification.

The technique relies on taking input 'neurons' which are connected to weighted network of neurons that are activated according to the inputs (activation properties are set by the designer). Activations are passed through the network until output neurons are activated by specific combinations of inputs. The output neurons represent the solution to the problem.

Inputs to the neural network can be, for example, handwriting, photographs or speech. The network can be trained to recognise specific examples of these inputs and the more examples it has, the more likely it is to recognise things from real-wold input.

Genetic algorithms are used to find the best solution to a problem by modifying possible solutions and then combining them with other solutions to improve the output. This process is modelled on the process of natural selection. Eventually over a number of iterations, the genetic algorithm will be able to select a suitable solution to the problem.

Learners are not expected to be able to provide detailed explanations or examples of the workings of the AI techniques listed, but they should be able to explain the principles behind how they work and their application. In particular, they should be able to critically analyse the impact of Artificial Intelligence on society. How will AI impact on the lives of individuals? How will the advent of 'smart' devices and 'smart' cities change the way people live and work? What impact will this have on jobs? Will there be a loss of blue collar jobs because of AI in a similar way that white collar jobs were lost because of the increasing automation of industry? A number of leading industry figures and academics have issued warnings about AI as a danger to humanity. Is this a realistic prospect? Is there a danger from the so-called AI singularity?

Outcome 2

This Outcome provides the learner with the opportunity of learning about the implementation of AI within computer games. Learners should study a range of different AI techniques used in computer games, including those bulleted in the Knowledge and Skills. Delivery should focus on the principles and ideas behind these techniques, learners are not expected to be able to provide a detailed work through (mathematical) or code implementation of the algorithms, but should be able to describe the steps required to simulate the technique.

Existing games can be used as case studies for some of the AI techniques. The game Command and Conquer is an example of AI pathfinding, while there are games that use intelligent agents, such as the god game Black and White or artificial life, like the game Creatures. Other games claim to provide increasingly intelligent adversaries, which can take advantage of game environments to try and defeat the player, including games like the Battlefield series.

It should also be noted that AI techniques are not perfect and sometimes result in non-player characters behaving strangely or inappropriately in certain situations, or showing certain predictable traits that make it easy for the player to anticipate and react to them.

The learner should reach an understanding of processes applied in AI and be able to explain them in answers to assessment questions.

Outcomes 3 and 4

The main aim for delivery of these Outcomes is to encourage learners to apply what they have learned in the previous two Outcomes to plan an intelligent game component. The tutor's role is to mentor the teams through the problem solving activity and encourage teamwork and cooperation.

These Outcomes provide the learners with the opportunity of working with others to solve problems. As the assignment progresses, there will be the opportunity to be creative, analytical and reflective as they get nearer to the final.

The problem(s) they are presented with will provide them with a significant challenge where they will have to work together as a team and demonstrate how they are planning to implement and provide possible solutions. Learners should work on this for a number of weeks as opposed to coming up with a quick solution.

Guidance on approaches to delivery of this unit

Delivery of this unit should be interesting, thought-provoking and stimulating, providing an insight into an area of industry that affects us in many ways and particularly in the context of computer games. Learners will be able to learn about AI in general as well as learning about the implementation of AI in games.

Exemplar materials could be used to highlight how to write evaluative statements and to develop skills in self-reflection.

Approximate scheduling for each Outcome can be allocated as follows:

- Outcome 1 — 15 hours
- Outcome 2 — 20 hours
- Outcomes 3 and 4 — 40 hours

Remaining hours are allocated to feedback and/or remediation.

Outcome 1 should focus on research, investigation and class discussions. The tutor can provide a framework and background information about the topics and learners should be able to carry out investigative tasks to build an understanding of the topics, these activities can be integrated with a programme of presentations and lectures from the tutor to facilitate further discussion of the implications and possibilities of AI, linking developments to their impact on society.

For the delivery of **Outcome 2** the tutor can use case studies of game play to demonstrate and highlight AI features used in computer games. Where facilities allow, the learners should be encouraged to play and research specific game(s) to gain understanding of the strategies employed. Formative assignments can be set where learners use the internet, books and/or magazines to investigate AI in games. The tutor can present information in the form of lectures and tutorials and a variety of case study materials and examples to cover all of the Knowledge and Skills for this Outcome. The tutor could also set smaller research based assignments where the learner has the opportunity to learn investigative skills in preparation for the assessment.

Guidance on approaches to assessment of this unit

Evidence can be generated using different types of assessment. The following are suggestions only. There may be other methods that would be more suitable to candidates.

Centres are reminded that prior verification of centre-devised assessments would help to ensure that the national standard is being met. Where candidates experience a range of assessment methods, this helps them to develop different skills that should be transferable to work or further and higher education.

Outcome 1 could be assessed by a set of extended response questions covering all of the Knowledge and Skills for Outcome 1 at least once. The extended response questions should be scored and candidates must gain at least 60% of the available marks to pass. Conditions should be closed-book with a time limit of 1 hour.

Candidates should not know in advance the items on which they will be assessed and different items should be sampled on each assessment occasion.

Outcome 2 could be assessed using an investigative assignment which is open-book and research based. The assignment will consist of a clearly defined set of instructions for the candidate to follow to ensure that all of the Knowledge and Skills for this Outcome are covered. It may be based on a case study of a strategy game or it can be specific instructions to elicit information to cover all of the Knowledge and Skills.

The candidate should be given time in the region of 10–12 hours to carry out research, collect or create materials, and construct a presentation of a series of 12–18 slides with concise wording and should include appropriate diagrams, charts or images. Alternatively, a large poster consisting of key words, diagrams and images could be used. Candidates should be able to talk about their work and answer any questions. A date for presenting work should then be agreed. A checklist should be used for marking; this will help to ensure that the assessment is valid and reliable and the instructions have been followed.

By undertaking this investigation, candidates will demonstrate that they can:

- explain the history and development of AI in games.
- describe the role of pathfinding in a computer game.
- describe the role of behaviour tree in a computer game
- describe the role and purpose of at least two search algorithms.
- explain the role of Intelligent Agents within a game.
- explain how case-based reasoning can be used in a game.
- explain the role of evaluation functions are used in games.
- explain how AI cheating is sometimes used to make game AI appear intelligent.
- demonstrate how AI techniques have been used in at least one game.

Use of a checklist would be beneficial during the candidate's presentation in order to ensure that s/he has addressed either orally or in the presentation, all of the Evidence Requirements listed above. A time limit of 15 minutes maximum is suggested for the presentation.

Outcomes 3 and 4

Candidates will work in teams of three or more, to produce evidence in the form of a single portfolio of work for the team which will cover all of the Knowledge and Skills for both Outcomes. Required contents of the portfolio are listed in the Evidence Requirements for these Outcomes.

In this assessment it is the processes employed to reach a solution that are important rather than the solution itself. It is hoped that an iterative approach will be taken by the teams where, upon reflection, they can justify a better solution. There are no right or wrong answers and they are not required to have any functional piece of code or technology in place, beyond a demonstration or walkthrough of the proposed solution, however the assessor must be satisfied that they can demonstrate all of the Knowledge and Skills listed.

The context of AI within a game provides an ideal problem base as there are many factors to consider. This context will also provide the candidate with a greater understanding of AI in games.

Teamwork culminates with the implementation of a confidential peer ballot where a tutor-devised pro forma will be completed to assess each candidate's contribution to the team. A cut off score can be used to determine the Outcome. Where a candidate has achieved a poor result they can be given the chance to be re-assessed by the tutor issuing a task for the individual(s) that is also agreed to, by the team.

The team could use a discussion forum to log team decisions and an individual blog, diary or video record could be kept by each candidate to monitor reflective thoughts, changes, amendments and the final evaluation.

The assessor may want to implement a checklist to ensure that the candidate has met the requirements for both Outcomes. During the problem solving assignment, the assessor should refrain from interfering or providing any form of feedback as the learning process requires the candidates to think, reflect and evaluate for themselves. Any feedback provided should only address the issues surrounding the recording of thoughts and actions. The final conclusion arrived at by the team should be defensible upon questioning and provide a reasonable conclusion for the allocated time frame.

Opportunities for e-assessment

E-assessment may be appropriate for some assessments in this unit. By e-assessment we mean assessment which is supported by Information and Communication Technology (ICT), such as e-testing or the use of e-portfolios or social software. Centres which wish to use e-assessment must ensure that the national standard is applied to all learner evidence and that conditions of assessment as specified in the Evidence Requirements are met, regardless of the mode of gathering evidence. The most up-to-date guidance on the use of e-assessment to support SQA's qualifications is available at **www.sqa.org.uk/e-assessment**.

Opportunities for developing Core and other essential skills

This Unit provides opportunities to develop some of the components of the following Core Skills:

- *Problem Solving* at SCQF level 6
- *Communication* at SCQF level 6
- *Working with Others* at SCQF level 6

All elements of the Core Skill of *Problem Solving* will be naturally developed and enhanced as learners undertake the unit. Effectiveness of solutions to problems are formally reviewed and evaluated on an on-going basis in reflective logs.

Skills are developed in accessing and evaluating a range of source materials undertaken by self-directed research. Analytical evaluation of AI could include a check on relevance, currency, future trends and effectiveness. If evidence is presented orally as part of a slide presentation, this will provide opportunities to practise complex verbal and non-verbal communication techniques and respond to questions confidently and in a way that progresses communication.

Elements of the Core Skill *Working with Others* are developed and enhanced as learners undertake the unit. The ability to converse effectively with team members in order to make decisions and present information is an essential contribution to the evidence required to pass this unit.

This Unit has the Critical Thinking component of Problem Solving embedded in it. This means that when learners achieve the Unit, their Core Skills profile will also be updated to show they have achieved Critical Thinking at SCQF level 6.

History of changes to unit

Version	Description of change	Date

SQA acknowledges the valuable contribution that Scotland's colleges have made to the development of SQA Advanced Qualifications.

General information for learners

Unit title: Artificial Intelligence for Computer Games (SCQF level 8)

This section will help you decide whether this is the unit for you by explaining what the unit is about, what you should know or be able to do before you start, what you will need to do during the unit and opportunities for further learning and employment.

The unit is about Artificial Intelligence (AI). AI is an area of increasing importance in industry, as a way of enhancing services and taking care of everyday tasks. In computer games, AI is what controls the characters and objects and makes them behave intelligently, or at least seem to behave intelligently.

What you will learn

- The field of AI and its impact on society
- How AI can contribute to a game
- To plan for implementing an intelligent component of a game
- Processes involved in problem solving
- How to critically evaluate

This unit will examine AI as a subject and how it applies computer games. You will examine the field of AI in general terms and look at some of the techniques that are applied to help systems appear intelligent. You will also look at how this field is impacting on society and how this might develop in the future.

You will then look at some specific examples of AI techniques for computer games. There are many types of characters and objects in games and making them appear intelligent depends on the nature of the game and the type of interaction involved. There are a variety of AI techniques that are applied to this problem and you will learn how some of them work and how they can be applied to computer games. You will examine a number of these techniques and create a presentation about them and their application to computer games.

Finally, you will work as part of a team in an assignment where you will produce a portfolio of evidence to demonstrate how you plan to implement an intelligent component of a game. You will have to think about the nature of the game you are presented with and link it back to some of the AI techniques you have already studied and show how these might apply to the game brief you are presented with. You will evaluate your solution and look at possible ways of improving it.

This unit will provide you with opportunities to develop the *Problem Solving, Communications* and *Working with Others* Core Skills.

This Unit has the Critical Thinking component of Problem Solving embedded in it. This means that when you achieve the Unit, your Core Skills profile will also be updated to show you have achieved Critical Thinking at SCQF level 6.