Unit 70: Computer Game Engines

Unit code: M/502/5771

QCF Level 3: BTEC National

Credit value: 10

Guided learning hours: 60

Aim and purpose

The aim of this unit is to introduce learners to the use of a game engine as a tool to produce game levels. Learners will investigate the purpose of game engines and explore their main components. Learners will use a 2D engine and a 3D engine to design and produce game worlds.

Unit introduction

The famous game *Doom* was a groundbreaking title; it brought into existence and popularised a new game-programming model, the 'game engine.' This modular, extensible and tweakable engine design concept allowed gamers and programmers to hack into the game's core to create new games with new models, scenery, and sounds, or put different twists called 'mods' on the existing game material. *CounterStrike, Team Fortress, TacOps* and *Strike Force* are among numerous new games created from existing game engines, with most using one of iD's Quake engines as their basis.

The term 'game engine' has come to be a standard part of a gamer's language. Learners need to have a knowledge and understanding of game engines as all games are developed using either a licensed game engine or a studio bespoke engine. It is therefore vital that learners have both a practical working knowledge and a basic technical understanding of 2D and 3D game engines. Through studying this unit learners should be able to understand the processes involved in the production of 2D and 3D game levels through the use of a game engine, the use of graphics and other game assets required to produce a game level.

The unit will examine what exactly is going on behind the scenes of a game engine to enable a game to display its graphics and textures, play sounds, give characters intelligence and trigger game events. Learners will become familiar with, and know what makes, a game engine an important tool in games development. Learners will investigate various game engines and systems used in the creation of an interactive game. They will understand how game engines can be used to develop mobile, 2D and 3D games. Learners will also demonstrate an understanding of the features of game engines, and will use a 2D and a 3D engine to create a game world for each type.

Learning outcomes

On completion of this unit a learner should:

1 Understand the purposes of game engines

2 Understand the functions of components of game engines

3 Be able to use a 2D game engine following industry practice

4 Be able to use a 3D game engine following industry practice.

Unit content

1 Understand the purposes of game engines

Types of game engine: 2D engines; 3D engines; mobile engines; game mods

Purposes: graphic rendering; collision detection; artificial intelligence (AI); sound; physics

2 Understand the functions of components of game engines

Graphic rendering: culling methods (eg, binary space partitioning (BSP), portal based, backface, view frustum, occlusion, contribution); rendering techniques (radiosity, photon mapping, ray tracing); lighting; textures; fogging; shadowing; depth testing; anti-aliasing; vertex and pixel shaders; level of detail

Animation systems: path-based; inverse kinematics; forward kinematics; particle systems

Systems: physics; effects; sound; networking

Artificial intelligence: AI agents (bots, non-player characters); world navigation (pathfinding, obstacle avoidance); behaviours; neural nets and fuzzy logic

Middleware: off-the-shelf components, eg rendering, physics, AI, animation, modelling, texturing, sound

3 Be able to use a 2D game engine following industry practice

Level design: eg genre, interpreting creative brief, storyboarding, asset management, level design maps

Assets: graphical (sprites, backgrounds, textures); behavioural (events, objects, scripts); sound, eg effects, music, ambience, dialogue; file types

Production: assets; actions; animation; game world; testing (alpha and beta, user testing)

Publishing: apps, executables, online platforms

Industry practice: reflect on development and outcomes (compared with original intentions, fitness for purpose, technical qualities); production skills (level design, workflow and time management, technical competence, teamwork)

4 Be able to use a 3D game engine following industry practice

Level design: eg genre, interpreting creative brief, storyboarding, asset management, level design maps

Assets: graphical (textures, meshes, models); events (triggers, actions, objects, scripts); sound, eg effects, music, ambience, dialogue; file types

Production: assets; events; lighting; animation; game world; testing (alpha, beta, user testing)

Publishing: apps, executables, online platforms

Industry practice: reflect on development and outcomes (compared with original intentions, fitness for purpose, technical qualities); production skills (level design, workflow and time management, technical competence, teamwork)

Assessment and grading criteria

In order to pass this unit, the evidence that the learner presents for assessment needs to demonstrate that they can meet all the learning outcomes for the unit. The assessment criteria for a pass grade describe the level of achievement required to pass this unit.

Assessment and grading criteria		
To achieve a pass grade the evidence must show that the learner is able to:	**To achieve a merit grade the evidence must show that, in addition to the pass criteria, the learner is able to:**	**To achieve a distinction grade the evidence must show that, in addition to the pass and merit criteria, the learner is able to:**
P1 describe the purposes of game engines using some subject terminology appropriately	**M1** explain the purposes of game engines with reference to detailed illustrative examples and with generally correct use of subject terminology	**D1** comprehensively explain the purposes of game engines with elucidated examples and consistently using subject terminology correctly
P2 summarise accurately the functions of components of game engines using some subject terminology appropriately	**M2** explain components of game engines with reference to detailed illustrative examples and with generally correct use of subject terminology	**D2** comprehensively explain components of game engines with elucidated examples and consistently using subject terminology correctly
P3 create a 2D game world following industry practice, working within appropriate conventions and with some assistance [CT; SM; RL]	**M3** create a 2D game world to a good technical standard following industry practice, showing some imagination and with only occasional assistance	**D3** create a 2D game world to a technical quality that reflects near-professional standards following industry practice, showing creativity and flair and working independently to professional expectations
P4 create a 3D game world following industry practice, working within appropriate conventions and with some assistance. [CT; SM; RL]	**M4** create a 3D game world to a good technical standard following industry practice, showing some imagination and with only occasional assistance.	**D4** create a 3D game world to a technical quality that reflects near-professional standards following industry practice, showing creativity and flair and working independently to professional expectations.

PLTS: This summary references where applicable, in the square brackets, the elements of the personal, learning and thinking skills applicable in the pass criteria. It identifies opportunities for learners to demonstrate effective application of the referenced elements of the skills.

Key	IE – independent enquirers	RL – reflective learners	SM – self-managers
	CT – creative thinkers	TW – team workers	EP – effective participators

Essential guidance for tutors

Delivery

It is suggested that teaching follows the order of the learning outcomes, starting with an introduction to the purpose of game engines and following that with a study of the components of game engines. Learners can then produce a 2D and a 3D game world using a 2D and a 3D game engine.

In game development terms, a game world is generally understood to consist of one or more levels. A level is a basic unit of location of a computer game's virtual world. To complete a game level, a gamer usually needs to meet specific goals or perform a specific task to advance to the next level, which may be as simple as walking from point A to point B, or can be far more complex. When the objective is completed, the player usually moves on to the next level.

Learners will need to appreciate the component parts within a game engine and the processes performed by the game engine to produce a playable game level. Learners will also need to understand the features of a game engine and the techniques and methods used in the development of a game level.

This unit could be taught through a variety of activities, such as lectures, group discussions, practical sessions and demonstrations. The largest proportion of time should be spent in practical sessions using 2D and 3D game engines.

Formal lectures and independent study may be the main method used to develop understanding of the purpose of a game engine. Learners could research the development history of 2D and 3D game engines and the game modifications known as 'mods'.

Learners will need access to a range of game design tools. These tools will allow learners to modify existing games or create their own.

Learners will need to appreciate the differences in level design planning and development for a 2D and a 3D game level. This is best achieved through learners planning their levels before using an engine. Using a 2D engine will demonstrate to learners how 2D sprites are used to give an illusion of 3D and how scrolling backgrounds are used to give an illusion of animation or movement. Learners will be expected to have a good working knowledge of the engine used to produce and test a playable 2D game world. This can be achieved through practical demonstrations and exercises.

Learners should also use a 3D game engine; this will enable them to understand the differences between a 3D and a 2D engine. As with 2D, learners will be expected to have a good working knowledge of the engine used to produce and test a playable 3D game world.

Reflective practice is an important part of games development and design. Learners should be encouraged to compare their development of 2D and 3D game work with their original intentions and requirements of the brief. This can be achieved by self-evaluation (using techniques such as peer and client testing).

Industry speakers and visits should be included where appropriate. Industry visitors could also, if possible, be involved in assessment.

Outline learning plan

The outline learning plan has been included in this unit as guidance and can be used in conjunction with the programme of suggested assignments.

The outline learning plan demonstrates one way of planning the teaching and assessment of this unit.

Topics and suggested assignments and activities
Introduction to unit and unit assessment.
Introduction to purpose of engines used in games. Learners: • receive lectures, demonstrations and hold discussions to examine why games engines are used to create games • receive lectures and hold discussions on the purpose of a game engine.
Assignment 1 – The Purpose of Game Engines Learners will write an article on the purpose of game engines for an online computer games ezine.
Introduction to the components of game engines. Learners will receive lectures and hold discussions on the components of game engines.
Assignment 2 – Game Engine Components Learners will write an article on the game engine components necessary for the production of computer games for an online computer games ezine.
Workshop sessions to develop practical 2D game development skills: • introductory lecture introducing 2D game engines • interpreting creative briefs to plan 2D game content • level design and asset management • game production and testing • presentation of work including review of own 2D game engine work.
Assignment 3 – Develop a 2D Game World Learners will produce and test a 2D game world.
Workshop sessions to develop practical 3D game development skills: • introductory lecture introducing 3D game engines • interpreting creative briefs to plan 3D game content • level design and asset management • game production and testing • presentation of work including review of own 3D game engine work.
Assignment 3 – Develop a 3D Game World Learners will produce and test a 3D game world.
Unit learning and assessment review.

Assessment

Evidence for assessment

To provide evidence of achievement of learning outcomes 1 and 2, learners must collate and present researched information and conclusions in a suitable form. This could be via a presentation or a report covering, for learning outcome 1, the purpose of graphics rendering, collision detection, artificial intelligence, sound, and physics and how they are used to develop a game, and, for learning outcome 2, graphic rendering, animation systems, systems, artificial intelligence and middleware describing how they work and function together as a game engine. Research may include extracts from books, journals, articles and material published on websites, blogs or videos, or in trade publications. If presentations are used, they must be recorded for the purposes of internal and external verification.

For some elements of these outcomes, and for some learners, a formal viva voce assessment might be appropriate. When more than one learner in a cohort is assessed in this way, care must be taken to ensure that all learners are asked equivalent questions, and that all are given equal opportunities to expand or clarify their answers. Interviewers must also ensure that questions are not phrased in such a way as to provide or suggest an answer. Formal vivas should be recorded for the purposes of internal and external verification and at least 50 per cent of such assessments must be internally verified.

To provide evidence of achievement of learning outcomes 3 and 4, learners must produce a 2D game world using a 2D game engine and a 3D game world using a 3D game engine respectively. The game world produced should consist of one of more actions such as walking from point A to point B, meeting specific goals, or performing a specific task or objective to advance the player to the next level.

Application of grading criteria

When applying the grading criteria tutors should follow the advice given below. Please note that any examples of evidence given here are indicative only. This advice is not inclusive and the examples need not be included in a learner's work in order for that learner to achieve the exemplified grade. For each of the criteria learners must present evidence that addresses each italicised sub-heading of the content for the learning outcome.

Pass

To achieve a pass grade, learners must achieve all the criteria at pass level. For each of the criteria learners must present evidence that addresses each italicised sub-heading of the content for the learning outcome.

P1: learners will describe the types and purpose of game engines. They will describe the purpose of 2D, 3D and mobile game engines, though for this grade the evidence will not necessarily be related to examples of particular game engines. Learners will provide correct and substantially complete descriptions of the types and purpose of a game engine, including graphic rendering, collision detection, artificial intelligence, sound and physics. A pass grade learner might note, 'A game engine is the core component of a video game. It handles rendering which allows us to see the models in the game world. It basically puts everything in the game together so it can be viewed on screen.'

P2: learners will provide correct and substantially complete descriptions of the functions and components of game engines. The evidence produced will describe components of game engines including graphic rendering, animation systems, systems, artificial intelligence and middleware, though at this grade the evidence will not necessarily be related through examples to particular game engines. For example, a learner might note, 'In computer graphics the renderer is viewed as one of the most important parts. The renderer allows us to see the models in the game world. It basically puts all the graphics features in the game together so it can be viewed on screen. With so much to do it needs a lot of processing power. It is the part that is most often criticised when viewed by those playing the game, as graphics can play a key role in how commercially successful a game will become.'

P1 and P2: evidence will show a basic understanding of technical terminology but learners will generally be unsure about this vocabulary and will make fairly frequent mistakes when they do use it.

P3: learners will produce a working 2D game world. Use of the 2D game engine to produce the 2D game world will be basic – for example, loading sprites, creating objects, adding events, adding actions and publishing the finished game world. Learners will demonstrate some development of the 2D game.

P4: learners will produce a working 3D game world. Use of the 3D game engine to produce the 3D game world will be basic – for example, loading textures, lighting, adding actions and publishing the finished game world. Learners will demonstrate some development of the 2D game.

P3 and P4: in terms of the aesthetic or creative qualities of their work, pass grade learners will not move beyond the conventional, but the conventions applied must be appropriate to the form or genre within which they are working. When engaged in practical or production activities, pass grade learners will need frequent assistance and support, though they will take note of and make use of this help when it is given. If they are in frequent need of such help but fail to make positive use of it, they should not be considered for a pass grade for this unit.

Merit

To achieve a merit grade, learners must achieve all the pass and all the merit grade criteria. For each of the criteria learners must present evidence that addresses each italicised sub-heading of the content for the learning outcome.

M1: learners will explain the purpose of game engines and how their advancement over the years has helped in the development of 2D, 3D and mobile games. Learners should also explain how game engines have helped game development. These explanations will be supported through detailed illustrative examples of particular game engines. Learners must mention graphic rendering, collision detection, artificial intelligence, sound and physics. For example, a learner might note, 'A game engine is the core software component of a computer game. It takes care of the rendering and other functions/technologies. It may well also take on additional responsibilities such as artificial intelligence (AI) and detecting collisions between game objects. But the most common element that a game engine provides is graphics rendering facilities 2D or 3D. Engine X is a good example of a modern game engine.'

M2: learners will give clear and correct explanations of functions and components of game engines showing how they work and function together. These explanations will be supported through detailed illustrative examples of particular game engines. The evidence produced must mention graphic rendering, animation systems, systems, artificial intelligence and middleware. A merit grade learner might note, 'Graphics rendering is viewed as one of the most important parts of a game engine. The renderer allows us to see the models in the game world properly lit, textured etc. It basically puts all the graphics features in the game together so it can be viewed on screen. With so much to do it needs a lot of processing power. About 50 per cent of the CPU's processing power is used to pass graphical information towards the renderer. Game graphics is the part that is most often criticised by those playing a game; it can play a key role in how commercially successful a game will become.'

M1 and M2: learners will use technical vocabulary for the most part correctly, but may make mistakes or be unsure about usage at times.

M3: learners will produce a working 2D game world using a 2D game engine including evidence of alpha and beta testing. They will use the 2D game engine competently to produce a 2D game world – for example, loading sprites, loading backgrounds, loading textures, creating objects, adding events, adding actions, adding sounds and publishing the finished game world. Learners will demonstrate competent development of the 2D game.

M4: learners will produce a working 3D game world using a 3D game engine including evidence of alpha and beta testing. They will use the 3D game engine competently to produce a 3D game world – for example, loading textures, meshes, models, lighting, adding actions, triggers, objects and publishing the finished game world. Learners will demonstrate competent development of the 3D game.

M3 and M4: learners will show facility and some confidence in relation to skills and the handling of equipment. Work will be approached methodically and with adequate preparation. Processes will be undertaken with care and, generally speaking, thought will be put into the work. Though learners might still be working within recognisable generic conventions, codes and conventions, whether aesthetic or technical, will not be slavishly copied but will be employed with some inventiveness. Learners at this grade might well need occasional support, particularly when dealing with more complex technology or trying to apply more sophisticated techniques. As with the pass grade learner, they will benefit from such support.

Distinction

To achieve a distinction grade, learners must achieve all the pass, all the merit and all the distinction grade criteria. For each of the criteria learners must present evidence that addresses each italicised sub-heading of the content for the learning outcome.

D1: learners will engage in a comparative discussion of the purpose of game engines, showing how they compare to one another and the advantages and disadvantages inherent in them, and fully explain how their advancement over the years has helped in the development of 2D, 3D and mobile games. Learners will show a full awareness of the purposes of game engines, supporting points made with clear arguments and examples which are elucidated to show how they carry the points being illustrated. Fuller and more extensive explanation, better application of examples and provision of argument to support points made will discriminate between this grade and the merit. A distinction grade learner might note, 'A game engine is the core software component of a computer game. Many people continually confuse the game with the actual game engine itself. They are not the same thing. The game engine can be used to make a particular game, but it can also be reprogrammed to accommodate information to build a completely different game as well. A simple way of explaining it is like this: think about a car engine and the actual car itself. You can take the engine out of a car and build another car body shell around it to make a different car just by reusing the engine. A game engine can be utilised in the same way. A game engine takes care of the rendering and other functions or technologies. It may well also take on additional responsibilities such as artificial intelligence (AI) and detecting collisions between game objects. But the most common element that a game engine provides is 2D or 3D graphics rendering facilities. Engine X is a good example of a modern game engine.'

D2: learners will provide a critical evaluation of functions and components of game engines. They will show a full awareness of particular components of game engines and how they work and function together. They will support points made with clear arguments and examples which are elucidated to show how they carry the points being illustrated. A distinction grade learner might note, 'The renderer is the most important part of every game engine, and it is usually where the building of a game engine begins. If you had no renderer you wouldn't be able to see anything. This is because the renderer visualises the scene for the player from information passed to it by the game engine. The CPU spends over 50 per cent of its processing time on the rendering process. If the game developers get the rendering wrong it can cause the whole game and company to look like a joke in the game world, so they have to get it right. The renderer's job is to give the game the excellent graphics that people love to see in games. If you have the best renderer available then you have the potential to make the best game from a graphics point of view. OpenGL and DirectX are well known for their rendering capabilities and are widely used in the professional market because of their reliability.'

D1 and D2: technical vocabulary will be secure and used correctly and confidently at all times.

D3: learners will produce a working 2D game world using a 2D game engine including evidence of alpha, beta and user testing. Learners will use the 2D game engine creatively to produce a 2D game world which has some qualities of originality, loading sprites, loading backgrounds, loading textures, creating objects, adding events, adding actions and adding sounds. Distinction grade learners will use the engine's scripting language to create more complex actions. They will publish the finished game world and will demonstrate effective development of the 2D game.

D4: learners will produce a 3D game world using a 3D game engine including evidence of alpha, beta and user testing. Learners will use the 3D game engine creatively to produce an original 3D game world which has some qualities of originality, loading textures, meshes, models, lighting, adding actions, triggers and objects. Distinction grade learners must use the engine's scripting language to create more complex actions. They must publish the finished game world and will demonstrate effective development of the 3D game.

D3 and D4: technical and production skills will approach the professional standard and work produced will bear comparison with professional work. Distinction grade learners will apply their technical skills not just with imagination but with ingenuity and even elegance, and codes and conventions will be used with occasionally surprising results. In all practical activity they will be capable of working autonomously and effectively. The term 'working independently' means that they are able to work on their own initiative, do not need constant support or supervision, give the work their full commitment, work positively and cooperatively with others, and meet deadlines. In other words, they have the kind of self-management skills that would be expected of them in a professional context. Note also that this criterion should not be taken to mean that learners do not seek advice or that they work without discussing things with their tutor, but rather that they are not dependent upon the support of others and that if they take advice they weigh it carefully for themselves.

Programme of suggested assignments

The table below shows a programme of suggested assignments that cover the pass, merit and distinction criteria in the assessment and grading grid. This is for guidance and it is recommended that centres either write their own assignments or adapt any Pearson assignments to meet local needs and resources.

Criteria covered	Assignment title	Scenario	Assessment method
P1, M1, D1	Assignment 1 – The Purpose of Game Engines	The learner is commissioned to write an article for a computer games ezine on the purpose of game engines.	• All preparatory notes. • Article as word-processed or electronic document, blog or vlog.
P2, M2, D2	Assignment 2 – Game Engine Components	The learner is commissioned to write an article for a computer games ezine on the game engine components necessary for the production of computer games.	• All preparatory notes. • Article as word-processed or electronic document, blog or vlog.
P3, M3, D3	Assignment 3 – Develop a 2D Game World	Brief from a producer to create a 2D game world.	• Planning notes. • All production documentation. • Personal reflective commentary.
P4, M4, D4	Assignment 3 – Develop a 3D Game World	Brief from a producer to create a 3D game world.	• Planning notes. • All production documentation. • 3D game world. • Personal reflective commentary.

Links to other BTEC units

This unit forms part of the BTEC Creative Media Production suite. This unit has particular links with the following units in the BTEC Creative Media Production suite:

Level 2	Level 3
	3D Environments
	3D Modelling
	Digital Graphics for Interactive Media

Essential resources

Learners will need access to a range of games on a variety of platforms. Access to the internet is essential for research. Learners will also need access to 2D and 3D game engine software on a PC platform.

Employer engagement and vocational contexts

Centres should develop links with local interactive media production studios which could be approached to provide visiting speakers, study visits or samples of typical products.

Delivery of personal, learning and thinking skills

The table below identifies the opportunities for personal, learning and thinking skills (PLTS) that have been included within the pass assessment criteria of this unit.

Skill	When learners are ...
Creative thinkers	generating ideas for a 2D and 3D game world level(s) trying out different ways of creating their game, following ideas through to complete a functioning product adapting their ideas as circumstances change
Reflective learners	reviewing and reflecting on their 2D and 3D game worlds and acting on the outcomes to modify and improve their work setting goals with success criteria for their production work inviting feedback on their own work and dealing positively with praise, setbacks and criticism evaluating their learning and experience to inform future progress
Self-managers	producing game world level(s) to be used in an interactive game seeking out challenges or new responsibilities and showing flexibility when circumstances change dealing with competing pressures, including personal and work-related demands responding positively to change, seeking advice and support when needed.

Although PLTS are identified within this unit as an inherent part of the assessment criteria, there are further opportunities to develop a range of PLTS through various approaches to teaching and learning.

Skill	When learners are ...
Independent enquirers	carrying out research into the purpose of game engines carrying out research into the functions of the components of game engines carrying out research to develop ideas for their own 2D and 3D game production
Team workers	if working in a group to produce a game, taking responsibility for their own role managing their personal contribution to and assimilating information from others in discussions to reach agreements and achieve results.

Functional Skills – Level 2

Skill	When learners are …
ICT – Use ICT systems	
Select, interact with and use ICT systems independently for a complex task to meet a variety of needs	handling game engine systems to create their game
Use ICT to effectively plan work and evaluate the effectiveness of the ICT system they have used	planning for the creation of their 2D and 3D game
Manage information storage to enable efficient retrieval	managing assets sourced and created for their 2D and 3D game
Follow and understand the need for safety and security practices	handling 2D and 3D game engine systems to create their games
Troubleshoot	handling 2D and 3D game engine systems to create their games
ICT – Find and select information	
Select and use a variety of sources of information independently for a complex task	sourcing assets for their game
Access, search for, select and use ICT-based information and evaluate its fitness for purpose	researching asset types and their limitations for use with their game engine
ICT – Develop, present and communicate information	
Enter, develop and format information independently to suit its meaning and purpose including: • text and tables • images • numbers • records	building and presenting their project portfolio showing their interpretation of their brief and their generation of ideas, documenting the management of their chosen assets, considering legal implications and reviewing their own work
Bring together information to suit content and purpose	
Present information in ways that are fit for purpose and audience	
Evaluate the selection and use of ICT tools and facilities used to present information	preparing a report on 2D and 3D game engine tools
Select and use ICT to communicate and exchange information safely, responsibly and effectively including storage of messages and contact lists	gathering feedback on their game engine work as part of their self-reflective practice

Skill	When learners are …
Mathematics	
Understand routine and non-routine problems in a wide range of familiar and unfamiliar contexts and situations	using estimation and calculation to plan game level layouts using estimation and calculation to work out the size of models and meshes for incorporation into level
Identify the situation or problem and the mathematical methods needed to tackle it	
Select and apply a range of skills to find solutions	
Use appropriate checking procedures and evaluate their effectiveness at each stage	
Interpret and communicate solutions to practical problems in familiar and unfamiliar routine contexts and situations	
Draw conclusions and provide mathematical justifications	
English	
Speaking and listening – make a range of contributions to discussions and make effective presentations in a wide range of contexts	taking part in brainstorming sessions to generate ideas as a response to a creative brief
Reading – compare, select, read and understand texts and use them to gather information, ideas, arguments and opinions	studying manufacturers' manuals to research game engine software
Writing – write documents, including extended writing pieces, communicating information, ideas and opinions, effectively and persuasively	creating their project portfolio incorporating ideas, notes, production documentation, testing reports, and reflective comment.