Scientific Research Publishing

Creative Education, 2026, 17(9), 1689-1705
https://www.scirp.org/journal/ce
ISSN Online: 2151-4771
ISSN Print: 2151-4755

A Critical Reflection on the Design and Delivery of the Graduate Apprenticeship Engineering: Design and Manufacture Degree

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How to cite this paper: Boyle, S., Burns, C., Cairns, M., Charlesworth, M., McConnachie, G., Ruddy, P., Sweeney, J., & Walker, S. (2026). A Critical Reflection on the Design and Delivery of the Graduate Apprenticeship Engineering: Design and Manufacture Degree. *Creative Education, 17,* 1689-1705.
https://doi.org/10.4236/ce.2026.179096

Received: July 1, 2026
Accepted: September 1, 2026
Published: September 4, 2026

Abstract

This article describes the development of an innovative work-based engineering degree that has been validated against the Skills Development Scotland Framework for the Graduate Apprenticeship in Engineering: Design and Manufacture (BEng Honours). The study evaluates the effectiveness of a hybrid delivery model, examining its impact on learner experience, motivation, and progression, while also considering the benefits for employers and the wider Scottish engineering sector. A qualitative evaluation of the competency-based pedagogical framework is undertaken through analysis of anonymised student data and marker feedback. The findings highlight the benefits of the Graduate Apprenticeship in supporting learner development, delivering employer return on investment, and contributing to the sustainability and growth of Scotland's engineering workforce.

Keywords

Graduate Apprenticeship, Professional Competence, Workbased Learning, Incorporated Engineer

1. Introduction

The University of Strathclyde Graduate Apprenticeship Engineering: Design and Manufacture (GA EDM) degree evolved from the Skills Development Scotland Framework designed by the associated Technical Expert Group (TEG) in the period of 2015-2017.

Through the collaborative workings of the TEG, which included significant representation from key industry stakeholders, key skills gaps within the Scottish engineering sector were identified and the core knowledge and understanding required to bridge those gaps were defined.

Further discourse between the University Faculty and key employer partners informed the curriculum design and delivery mode of the Strathclyde GA EDM degree, leading to the successful launch in 2017 of a hybrid workbased learning degree.

The graduate apprentices acquire underpinning knowledge and understanding via a blended and online learning delivery mode whilst the core engineering competencies (UK Standards for Professional Engineering Competence, IEng) are developed through an integrated workbased learning curriculum which allows each Graduate Apprentice to develop a portfolio of evidence of engineering competencies across the 4 years of study.

The hybrid (blended) delivery model adopted within the University of Strathclyde's Apprenticeship Degrees evolved from institutional expertise in the design of MOOCs. The blended delivery model takes the form of monthly on-campus days complemented by an online delivery mode which supports active learning and is underpinned by "Gilly Salmond's Five Stage Model for Online Learning" (Salmon Five Stage Model) and embeds a model of structured online activities, peer interaction, collaborative learning, and learner engagement in a Moodle based virtual learning environment (Salmon, 2013).

This online learning model was enhanced by a faculty strategy to monitor learner engagement which enabled targeted intervention of "at risk" candidates. The at-risk intervention strategy is explicitly defined within the University of Strathclyde Graduate Apprenticeship Tripartite Agreement (TPA) which defines the roles and responsibilities of the University, the Employer and the Graduate Apprentice. Critically, the TPA advises that the University will "support and manage the learning throughout the degree programme using a range of strategies including monitoring of student progress and student engagement, thereby enabling targeted interventions where impediments have been identified or progress is unsatisfactory".

Any potential technological barriers were mitigated through the provision of university-issued laptops with access to the necessary software licences and a responsive IT support team should impediments arise.

2. Curriculum Design

The GA EDM curriculum design resulted in a broad engineering curriculum in the first two years of the degree (**Figure 1**) with the opportunity for specialisation in Year 3 and Year 4 of the degree in 3 potential pathways: Design Engineering; Mechanical Engineering or Electronic and Electrical Engineering (please see **Figure 2**).

During Years 1 and 2 of the degree, the graduate apprentice studies 4 core 30 credit modules addressing Mathematics and Numerical Tools; Design and Production; Mechanical Engineering Principles and Electrical and Electronic Engineering Systems. Each of the 6 engineering classes includes a 10 credit workbased learning assignment which is assessed on an "achieved / not yet achieved" competency basis.

Year 1		
Term 1	Term 2	Term 3
Design and Production 1	Mechanical Engineering Principles 1	Electronic and Electrical Engineering Systems 1
Mathematics and Numerical Tools 1		
In order to progress to Year 2 of the degree a student must have accumulated at least 120 credits from the course curriculum		
Year 2		
Term 1	Term 2	Term 3
Design and Production 2	Mechanical Engineering Principles 2	Electronic and Electrical Engineering Systems 2
Mathematics and Numerical Tools 2		

Figure 1. Yr 1 and Yr 2 curriculum.

Year 3		
A total of 60 credits must be studied from a range of approved optional classes in parallel with a 60 credit workbased project (Class. EO300)		
Term 1	Term 2	Term 3
Structure and Properties of Engineering Materials (20 credit Level 3)	Advanced Engineering Production Techniques (20 credit Level 3)	Digital Electronics and Embedded Systems (20 credit Level 3)
Sensors, Systems, Signals & Instrumentation (20 credit Level 4)	Applied Mechanics and Machine Design (20 credit Level 4)	Design for X (20 credit Level 6)
	Key Power Systems, Concepts & Foundations (20 credit Level 3)	
EO300 Engineering Project A (60 credits/ workbased)		
In order to progress to Year 4 of the degree a student must have accumulated at least 360 credits from the course curriculum		
Year 4		
A total of 60 credits must be studied from a range of approved optional classes in parallel with a 60 credit workbased project (Class EO400)		
Term 1	Term 2	Term 3
Sensors, Systems, Signals & Instrumentation (20 credit Level 4)	Applied Mechanics and Machine Design (20 credit Level 4)	Design for X (20 credit Level 6)
Production Operations and Quality Management (20 credits Level 4)	Robotics & Control (20 credits Level 4)	Energy Fundamentals & Applications (20 credits Level 4)
	Power Systems Operation, Control and Protection (20 credits Level 4)	
	Principles and Applications of Non Destructive Evaluation. (20 credits Level 4)	
EO400 Engineering Project B (60 credits/workbased)		

Figure 2. Yr 3 and Yr 4 curriculum.

Year 3 and 4 of the degree are designed to develop higher level cognitive skills and enable the continued integration of knowledge, professional competencies and transferable skills via two 60 credit industry based project modules (typically their day job) through which they design, manage and report the outcomes of the employer defined activity. In parallel with the 60 credit workbased project. the Year 3 and Year 4 curriculum affords further opportunities for specialisation via study of a selection of optional modules chosen from an approved list.

Since its inception, the graduate apprenticeship degree has attracted more than 60 employer partners spanning a diverse range of sectors, including defence, aerospace, manufacturing (textiles, electronics, and biomedical devices), and specialist engineering services such as the design and installation of power earthing systems. This breadth of industrial engagement has informed the development of a broad-based engineering curriculum, with opportunities for learners to pursue greater specialisation during the final two years of the programme as highlighted in Figure 2.

3. Aims

This paper describes the pedagogy of workbased learning in the GA EDM degree and highlights the potential benefits to the graduate apprentices, the employer and the wider engineering community.

It reflects on the strategies which have ensured learner success since the launch in 2017, the importance of employer stakeholder engagement and summarises lessons learned.

4. Methodology

This article draws upon the collective experiences of the GA EDM Programme Team, comprising the Programme Director and Work-Based Learning Advisers, alongside the experiences and outcomes of six graduating cohorts.

The data has been collated from a range of sources including anonymised student feedback extracted from (voluntary) Student Module Evaluation surveys, Annual Programme reviews and on some occasions reflect the public comments (e.g. LinkedIn or Scottish Engineering or Skills Development Scotland sources) shared by individual Graduate Apprentices when accepting internal company awards, national Apprenticeship awards or sharing their successful IEng or CEng registration outcomes.

Student Module Evaluation is an institutionally governed component of the University of Strathclyde's enhancement and quality framework. Managed through the University's Directorate of Education Enhancement the university-wide approach provides a consistent mechanism for gathering, analysing and responding to student feedback on module design, delivery and assessment. Results are considered at module, departmental and programme levels and contribute to evidence-informed enhancement activity. Module leaders receive module-level reports with student identifiers removed and free-text comments are separated from individual responses to reduce the risk of identifying students.

The measure of employer benefits reflects: 1) explicit oral feedback gathered from GA EDM employer partners via the frequent GA Employer Forum events, 2) the insights presented by a representative of a strategic employer partner during a 2024/25 GA Employer Forum event and 3) other discussions with the Programme Director and industry Early Careers Specialists/ Apprentice Managers during the quarterly review meetings.

Calculation of Student Progression data:

$$\text{Proportion of Population Calculation}\,(\%) = \frac{\text{Number Achieving Award}}{\text{Initial Population Size}} \times 100$$

Student withdrawals are represented by the proportion exiting with an "Exit Award" e.g. Certificate of Higher Education, Diploma of Higher Education or an ordinary B. Eng degree.

The inclusion of the anonymised student workbased learning reflective account is made with the explicit consent of the Graduate Apprentice and their Apprentice Manager.

5. Findings

5.1. Benefits and Challenges of a Hybrid Delivery Workbased Degree

Peer learning and collaborative working are embedded throughout the programme, beginning with the Graduate Apprentice Engineering Design and Manufacture (GA EDM) annual induction event. These approaches are further reinforced within the Year 1 and Year 2 Design and Production modules, where learners engage in both individual and group-based assignments. This enables them to build and apply key professional skills, including teamwork, communication, problem-solving, and effective collaboration within engineering contexts.

From a learner perspective, hybrid delivery offers increased flexibility, enabling apprentices to engage with their studies at times and locations that best align with their individual learning preferences and professional commitments and reflects effective practice identified by Gudonienė et al. (2025). Furthermore, the programme's "at risk" intervention strategy provides targeted academic and pastoral support, which is particularly valuable during the early stages of study when some apprentices are still developing the self-regulation, time-management, and independent learning skills required for success in higher education (Wolters & Brady, 2021). The availability of online learning resources throughout all four years of the programme further enhances accessibility, supporting ongoing revision, knowledge retention, and the reinforcement of learning across the degree.

For employer partners, the hybrid delivery model offers a flexible and cost-effective approach that supports productivity, broadens recruitment opportunities, and enables graduate apprentices to integrate learning more effectively with their day-to-day work. Critically, the focus on professional competence and behaviours within the GA EDM degree provides the learners with a scaffold through which to evidence their professional development and gives their employers a credible evidence base which may validate the Graduate Apprentice's statements of performance in any annual employee review.

5.2. Student Progression and Strategies for Learner Success

Despite the hybrid blended delivery model with only one day per month on campus, the progression statistics for the degree programme are very good. Table 1 illustrates the outcome for the cohort recruited in 2022/23. A noticeable trend seen in all cohorts thus far is that progression to year 3 of the degree typically leads to the award of the B. Eng (Honours) degree, with only 1.11% of said Year 3 population failing to complete Year 4 of the degree. In these rare occurrences, the candidates exiting with an ordinary degree explained they had achieved significant internal promotions and elected to exit with the ordinary B.Eng. degree, thereby freeing up more time for their families.

Candidates exiting with a Cert. HE or Dip. HE award have typically found the work life study balance too challenging and have communicated this via their employer representative and/or the University's Voluntary Course Withdrawal form.

Table 1. Typical cohort (2022/23) progression statistics.

Achieved Award	Proportion of Population (n = 38)
B. Eng (Honours) degree	35 (92% intake)
B. Eng Degree	0
Diploma of Higher Education in Engineering: Design and Manufacture	1 (2.6%)
Certificate of Higher Education in Engineering: Design and Manufacture	2 (5.2%)

Proportion of Population Calculation = (Number Achieving Award/Initial Population Size (38)) × 100.

There are several factors which have contributed to cohort success including:

1) The effective use of data analytics to monitor online learner engagement which results in interventions from Programme Team should a candidate be disengaged without explanation.

2) Regular one-to-one meetings between the Learning Adviser and the Graduate Apprentice facilitated timely discussions around each work-based learning assignment while also providing an important element of pastoral support.

3) Close collaboration with employer partners to ensure they understood the academic demands placed on their employees and enabled consideration of additional protected study time where apprentices required extra support to successfully manage their studies.

5.3. Partnership Working with Employers

Employer partnership has been integral to the Graduate Apprenticeship programme since its inception in 2017. Employer feedback continues to inform programme review, module development and curriculum evolution, reflecting QAA's expectation (QAA, 2018) that universities and employers work collaboratively to support learning, assessment and the quality of the apprentice experience.

This employer partnership working is further realised via the Programme Team's provision of an annual employer facing (virtual) workbased learning workshop with further discussion of the mode of workbased learning at the frequent GA Employer Forum events.

This approach has ensured the continued attractiveness of the degree to a diverse range of engineering organisations, supported the long-term viability of the GA EDM programme, and provided Graduate Apprentices with confidence that both their employers and University staff are committed to delivering a relevant, industry-informed and high-quality degree apprenticeship experience. This further aligns with QAA guidance (2018), which emphasises the importance of partnership between higher education institutions and employers in supporting workbased learning and the overall quality of the apprentice experience.

5.4. Designing a Competency Based Framework for Graduate Apprentice Engineers

The pedagogical design ensured that each of the 6 foundation WBL assignments undertaken in the first two years of study and the subsequent 60 credit workbased projects are an integral part of the degree programme, are credit bearing and are not achieved via simulated activity or additional employee tasks unrelated to their core engineering role.

The UK Standard for Professional Engineering Competence and Commitment (UK-SPEC, 4th Edition), Engineering Council (2020), defines the competence and commitment requirements that engineering professionals must meet to qualify for each professional title of Incorporated Engineer and includes the following five generic areas of competence and commitment:

A) Knowledge and understanding

B) Design and development of processes, systems, services and products

C) Responsibility, management or leadership

D) Communication and inter-personal skills

E) Professional commitment Career Development and Progress

These core engineering competencies (UK Standards for Professional Engineering Competence, IEng) are developed through an integrated workbased learning curriculum across the 4 years of the B. Eng (Honours) degree. Each workbased learning assessment has three mandatory elements, namely: a Reflective Account with Skills Analysis, a collation of relevant evidence of engineering competency and an evidence matrix with justification for the level of competence claimed against the criteria, please see **Figure 3**.

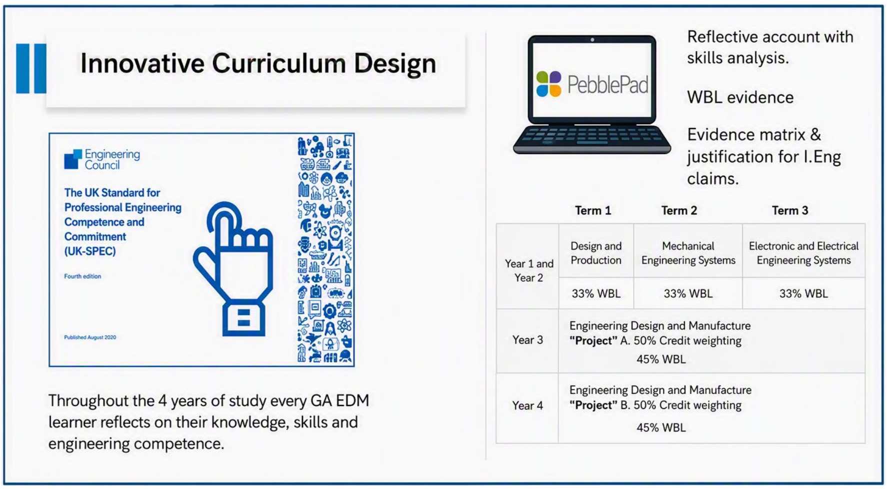

Figure 3. Achievement of the above IEng competencies is demonstrated via the evidence collated by the learners in their Pebble Pad e-portfolio, mapped through an evidence matrix which includes a justification for each competence claimed and validated by their University Workbased Learning (WBL) Advisors.

The Graduate Apprentices are expected to integrate their academic learning with critical reflection on its relevance to workplace issues, including their own professional practices and behaviours. This approach enables them to develop a deeper understanding of the engineer's role within the workplace and wider community.

Cognisant of the heterogeneity of the Strathclyde GA EDM student population in terms of professional experience and engineering specialisms, an inclusive strategy for recognising academic credit gained via workbased learning was designed which included 4 levels of competency, namely Awareness (A), Supervised Practitioner, (SP), Practitioner (P) or Expert (E), refer to Figure 4 for definitions.

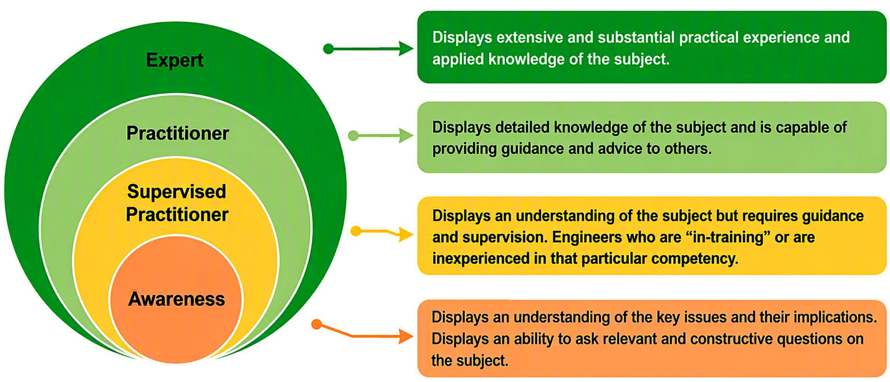

Figure 4. Definition of competence claim levels.

The 4 levels of competence (A, SP, P and E) which the graduate apprentice may claim for a particular IEng competence has ensured the degree meets the needs of a diverse learner population which includes established engineers looking to up-skill via degree studies, graduates of other disciplines changing career direction and early career candidates (typically new school leavers) with no industry experience when they enrol on the degree programme.

This competency-based framework has provided further benefits to the University by enabling it to accommodate a changing demographic profile within the Graduate Apprenticeship cohort. In 2017, 97% of entrants were existing employees using the degree primarily as a means of upskilling. By comparison, the 2025 intake comprised 56% upskilling candidates, indicating a growing proportion of entrants commencing the degree with limited or no meaningful industry experience.

5.5. Maintenance of Rigorous Academic Standards and Robust Assessment Practices

Recognising the innovative nature of this work-based learning model, the Programme Team invested substantial effort in defining and implementing rigorous assessment criteria and marking schemes to promote consistency, transparency, and objective evaluation.

To ensure an objective assessment is undertaken with feedback tailored to each graduate apprentice's submission, the evidence gathered via the e-portfolio is subject to appropriate quality control using the VARCS criteria (outlined below) as a method of ensuring a consistent approach to assessment of what is a widely variable body of apprentice evidence, whilst ensuring it meets the academic standard set by the university and by the Engineering Council standard for IEng status.

The VARCS criteria (Scottish Qualifications Authority (SQA), 2024) is a set of principles that guide assessors to ensure assessments are fair and aligned with qualification standards. Application of the VARCS criteria ensures that the work-based evidence submitted is confirmed as being Valid, Authentic, Reliable, Current and Sufficient by the Learning Adviser (marker) and then the level of competence claimed is considered.

The sufficiency and level of evidence submitted are key determinants when confirming the graduate apprentice's level of engineering competence against one of 4 internally recognised categories: Awareness, Supervised Practitioner, Practitioner or Expert.

5.6. Facilitating the Incremental Development of Professional Competence

Within Year 1 and Year 2 the workbased learning assignments are assessed on an achieved/not yet achieved outcome, and each assignment includes a formative submission at the delivery midpoint of the module which allows individual feedback on the Reflective Account and guidance on the quality, relevance and level of evidence submitted.

All 6 of the workbased learning assignments addressed in the first two years of study focus on a topic which may be addressed by a wide range of engineering backgrounds with the level of professional competence being reflected in the breadth and quality of evidence the graduate apprentice is able to map to the UK SPEC for IEng.

For example, the Year 2 Mechanical Engineering Principles workbased learning assignment requires the graduate apprentice to:

Identify a specific metal used in product manufacture within your workplace that has been selected for having the most suitable mechanical properties. State a further two metals that could be potential alternatives and describe why these were not the material of choice.

Below is an anonymised example of the Reflective Account (Figure 5(a)) of an early career engineer addressing the above assignment and the Learning Adviser evaluation of their skills matrix and evidence list (Figure 5(b)).

Mechanical Properties

In my workplace, material selection plays a critical role in ensuring process capability, particularly within shot peening, which is classified as a special process. One key example is the use of high-carbon cast steel shot, with a hardness range of approximately 45-52 HRC **(2.03.03)**, selected to achieve a controlled balance between effective plastic deformation of the component surface and durability of the media itself. While the shot is not part of the final product, I have come to recognise that its mechanical properties directly influence fatigue life, making material selection integral to product integrity.

A more significant learning experience for me was the decision to change a shot peen fixture material from aluminium **(2.03.01)** to steel **(2.03.02).** Initially, aluminium was selected due to its low density, ease of machining, and flexibility for quick design modifications. At the time, my focus was largely on manufacturability and handling efficiency. However, through operational use, it became evident that this decision did not fully account for the mechanical demands of the process.

The fixture was exposed to continuous high-velocity impact from the shot media, which led to progressive wear on critical location features. I observed that this degradation resulted in a loss of dimensional accuracy, reducing repeatability in how components were presented to the shot stream. This introduced variability in coverage and intensity, increasing the need for inspections, adjustments, and the potential risk of rework. Reflecting on this, I recognised that I had underestimated the significance of wear resistance and long-term stability when selecting the initial material.

Although aluminium offered advantages in terms of manual handling and reduced weight, these benefits were outweighed by the impact on process control. Shot peening requires consistent and repeatable positioning to maintain compliance with strict process specifications. I realised that the fixture must not only hold the component securely but also retain its geometry over extended production cycles without degradation.

Through comparing material properties, steel became the more appropriate choice. Its higher hardness, yield strength, and resistance to abrasive wear provide improved durability under repeated impact loading. Additionally, steel offers greater stiffness, reducing the likelihood of deformation under clamping forces and vibration. An important insight was that when the fixture hardness exceeds that of the shot media, the fixture effectively "conditions" the process, maintaining its geometry rather than being worn away by it.

In parallel, I evaluated alternative materials such as brass **(2.03.05)**. While brass offers excellent machinability, it lacks the mechanical strength, hardness, and fatigue resistance required for a high-impact environment. This reinforced my understanding that material selection must be driven by service conditions and mechanical requirements, rather than convenience in manufacture alone.

I also reflected on compliance and best practice within special processes. Shot peening is highly sensitive to variation, and even minor changes in fixture condition or part positioning can have significant effects on fatigue performance. By selecting steel, I aligned the fixture design more closely with the expectation that tooling used in controlled processes must be robust, stable, and capable of maintaining repeatability over time.

Overall, this experience marked a shift in my engineering approach. I moved from prioritising short-term manufacturability to taking a more holistic view that considers mechanical performance, process capability, safety, and lifecycle cost. It highlighted the importance of learning from operational feedback and continuously refining design decisions. As a result, I now place greater emphasis on aligning material selection with real-world conditions to ensure reliability, consistency, and quality within manufacturing processes.

The new revised fixture **(2.03.04)** is now being used within the process (**2.03.06)** and has been reliable and giving me repeatable results every time.

(a)

Competence	Level Awarded by Assessor	Evidence Agreed
A1 - Have maintained and extended a sound theoretical approach to the application of technology in engineering practice.	SP	Supervised Practitioner 2.3.04, 2.3.06 Awareness: the rest
A2 - Use a sound evidence-based approach to problem-solving and contribute to continuous improvement.	SP	SP: 2.3.04
B1 - Identify, review and select techniques, procedures and methods to undertake engineering tasks.	SP	Supervised Practitioner 2.3.06 Awareness: the rest
B.2 - Contribute to the design and development of engineering solutions.	SP	SP: 2.3.04
B.3 - Implement design solutions for equipment or processes and contribute to their evaluation.	SP	Supervised Practitioner 2.3.04, 2.3.06
C.4 - Take an active role in continuous quality improvement.	SP	Supervised Practitioner 2.3.04, 2.3.06
D.1 - Communicate effectively with others, at all levels, in English.	SP	Supervised Practitioner 2.3.04, 2.3.06

(b)

Figure 5. (a) An example of the Graduate Apprentice Reflective Account, with Marker Evaluation of Evidence and Level of Competence Claimed; (b) Learning Adviser evaluation of their skills matrix and evidence list.

Completion of the Year 3 and Year 4 60 credit workbased project modules provides a scaffold for each graduate apprentice to demonstrate skills in project management and execution, stakeholder analysis, risk management and communication.

The Year 3 and Year 4 workbased project assignments are a combination of formative and graded summative submissions. At the summative stages, each graduate apprentice presents their successful UK-SPEC skills claims and justifies their achieved competence level using a combination of evidence from their project work and written submissions. Marks are allocated for the depth and breadth of successful claims, and the quality and accuracy of how each graduate apprentice presents their claims and supporting evidence.

Each graduate apprentice's critical thinking, future thinking and self-awareness are assessed further in summative workbased reflections about project achievements, skills used, lessons learned and future development requirements that were identified during the project. Professional behaviours such as commitment to achieving objectives, making project decisions, recording work performed and project organisation are also subject to summative assessment. The acquisition of skills in critical thinking, future thinking, self-awareness, problem solving & collaborative skills are also recognized via the integrated workbased learning assignments.

Graduate Apprentice feedback on the benefits of the 60 credit workbased projects is constructive and typically positive as illustrated in the anonymous student feedback from 2024/25 academic session.

5.7. Please Tell Us about Any Aspects of the (EO400) Module That You Particularly Like

Comments
I found both project reports challenging but rewarding. I found I had to dive into researching new areas to progress. The format drove me to execute my project well and experiment with different methodologies. The workbased learning is a great way of feeling that the effort I'm putting in at work and the competency I demonstrated is not lost in the curriculum.

The authors acknowledge the limitations of this reflective and internally collected feedback which may be subject to evaluative bias. While these sources provide valuable contextual insight, they do not establish that observed outcomes are attributable solely to the programme delivery model.

5.8. Evidence of Sectoral Impact & Employer Benefits

Scottish Graduate Apprenticeship degrees have been developed to combine academic knowledge with skills development, enabling participants to become more effective and productive in the workplace while supporting the skills needs of employers and the wider economy (Scottish Funding Council, 2025).

The Strathclyde GA EDM workbased project model is an innovation of the degree which is highly valued by the EDM employer partners and their apprentices and is believed to be a key factor in the success of the GA EDM apprentices in several national awards including the Skills Development Scotland Scottish Apprenticeship Awards (2018, 2019, 2021 and 2026), The Hammerman Award for Apprentice of the Year (2024 and 2026), the IMechE Project of the Year (2024) and the Scottish Engineering Graduate Apprentice of the Year (2024 and 2026).

These national awards recognised the contribution of each Graduate Apprentice to their organisation and typically reflected their achievements during the final year 60 credit workbased project. For example, the 2026 Scottish Engineering Graduate Apprentice of the Year Award recognised the contribution of a "Ritchie Precision Graduate Apprentice for his project focusing on introducing Industry 4.0 principles to the shopfloor and improving the control of the company's CNC programs", Scottish Engineering (2026) Annual Award Winners.

There are innumerable examples of the positive impact of the Strathclyde GA EDM degree on Scottish engineering organisations, however, due to the commercial confidentialities and also the International Traffic in Arms Regulations compliance restrictions of many of the workbased projects, very limited detail of the wider impact of the individual projects may be publicly disclosed. Below is a top-level summary of a GA EDM Year 4 workbased project:

GA Project Role (Principle Mechanical Engineer). Module EO400 (60 Credit Workbased Project).
Project Title: Implementation of a Holistic Maintenance Approach to Maximise Production Efficiency.
Outcome/ Benefit 1: GA implemented company group initiative called SMART mobile maintenance incorporating planned training, employee development including new software/hardware.
Outcome/ Benefit 2: There was a reduction in downtime from 6.6% to 6.1%, showing progress in the new maintenance system and estimated plant savings to £877,374.68

5.9. Responding to Employer Needs

The evolution of the GA EDM curriculum has been informed by a range of internal and external factors, with employer voice playing a central role in shaping curriculum development. Engagement with industry stakeholders has provided valuable insight into the changing knowledge, skills and competencies required within the engineering sector, enabling the programme to remain responsive to emerging workforce needs.

In response to this feedback, four new 20-credit optional classes have been introduced across the final two years of the degree. This development provides greater flexibility for apprentices to tailor their learning towards relevant areas of professional and sectoral interest, while strengthening the alignment between academic provision, workplace practice and the evolving requirements of the engineering profession.

Additional drivers for curriculum change have emerged from global priorities, including UNESCO's Education for Sustainable Development (ESD) agenda, as well as the significant emphasis placed by many employer partners on the professional standards and guidance promoted by Scottish Engineering.

Scottish Engineering, the membership and employers' organisation representing the engineering and manufacturing sector in Scotland, provides a collective voice for engineering businesses and supports organisations in addressing the economic, technological, workforce and policy challenges affecting the sector.

Scottish Engineering views sustainable development as an integral part of the future of engineering and manufacturing, requiring businesses to combine decarbonisation, resource and energy efficiency, technological innovation and responsible business practices with long-term economic resilience and competitiveness.

This fits particularly well with UK-SPEC IEng competence, because it provides a strong industry context for demonstrating how an apprentice applies current and developing technologies responsibly, contributes to engineering solutions, considers environmental and societal impacts, and supports continuous improvement and sustainable outcomes.

Considering the growing recognition of sustainable development within the sector, and in response to the Faculty-wide requirement to align with the University's Strategic Plan 2030, particularly KPI 15, which aims to ensure that:

"All education programmes have programme level learning outcomes related to education for sustainable development by 2027 which encompass the integration of the UNESCO Education for Sustainable Development skills and competencies, the UN Sustainable Development Goals and appropriate pedagogical methods."

The Programme Team undertook a mapping exercise to identify existing areas where Education for Sustainable Development, Entrepreneurship and EDI (3Es) are addressed and explicitly assessed across the 4 years of study. This review identified the mandatory workbased projects as an ideal focus for further integration of the 3ES, leading to a change in the Module Learning Outcomes and a refocussing of the topic for the individual oral assessments on the E Criteria of the UK SPEC IEng. This change required the Graduate Apprentice to explain how they exercise ethical responsibilities, comply with codes of conduct, contribute to sustainable development & evidence CPD during their 600 hour workbased project.

6. Reflections and Lessons Learned

Whilst a hybrid delivery model was the preferred model of key employer partners, the University was cognisant of the risk associated with less frequent in person delivery. However, the regular schedule of Graduate Apprentice meetings with their Faculty Workbased Learning Adviser, coupled with monitoring of learner engagement through data analytics mitigated the risk of learner withdrawal.

Peer learning and collaborative working are embedded throughout the programme, beginning with the Graduate Apprentice Engineering Design and Manufacture (GA EDM) induction event. These approaches are further reinforced within the Year 1 and Year 2 Design and Production modules, where learners undertake both individual and group-based assignments, developing teamwork, communication, and problem-solving skills.

From a learner perspective, hybrid delivery offers increased flexibility, enabling apprentices to engage with their studies at times and locations that best suit their individual learning needs and professional commitments which resonates with the effective practice highlighted by Gudonienė et al. (2025). In addition, the programme's "at risk" intervention strategy provides targeted support, particularly during the early years of study when some apprentices are still developing effective time-management and independent learning skills.

The availability of online learning resources throughout all four years of the programme further enhances accessibility, supporting ongoing revision, knowledge retention, and the reinforcement of learning across the degree.

Current literature recognises many challenges of hybrid delivery including the risk that the GAs may feel less connected to the University community and acknowledgement that a lack of community may adversely affect the learning experience and willingness to seek tutor support (Hayes & Tucker, 2021). In the GA EDM degree, this risk is partially addressed via the annual mandatory on-campus induction sessions, the closed cohort delivery of the monthly on-campus days, the constructive approach of the Staff Student Liaison Committee and the responsiveness of module teaching teams who provide additional synchronous tutorial sessions where the need for additional tailored support has been recognised.

For employers, the hybrid delivery model offers a flexible and cost-effective approach that supports productivity, broadens recruitment opportunities, and enables graduate apprentices to integrate learning more effectively with their day-to-day work. Critically, the focus on professional competence and behaviours with the GA EDM degree provides the learners with a scaffold through which to evidence their professional development and their employers a credible evidence base which may validate the Graduate Apprentice's statements of performance in any annual progression review.

Furthermore, the strategy of early intervention and exception reporting of poor performance or unexplained low GA engagement to employers has resulted in high learner retention and progression statistics (refer to **Table 1**) compared to the national data published by Skills Development Scotland (2025). For example, the Strathclyde 2017 GA EDM cohort had a 90% achievement rate compared to a national rate of 71.9% for the same period.

Looking to apprentice loyalty and employer return on investment, more than 90% of Strathclyde GA EDM graduates have remained with their apprenticeship employer following graduation, exceeding the retention rates identified by Smith et al. (2026). Such retention provides a valuable mechanism for employers seeking to mitigate the challenges associated with an ageing workforce and to develop a sustainable talent pipeline. In addition, the alignment of the programme with the requirements for professional registration creates further organisational value through the development of professionally competent engineers, supporting organisational resilience, regulatory compliance, continuous improvement, and commercial competitiveness (Smith et al., 2026).

The strategic investment in a new category of staff role i.e. "Learning Adviser" is one of the USPs of the Strathclyde GA model which is valued by employer partners and has enabled the development of an innovative and impactful model of workbased learning.

In addition to supporting Graduate Apprentices, the Learning Advisers play a key role in the annual GA EDM Employer Work-Based Learning Workshop. This workshop is designed to enhance employers' understanding of the Work-Based Learning model and to support them in maximising opportunities for the Graduate Apprentices to evidence their knowledge, skills, and professional behaviours against the competencies and criteria required for UK-SPEC Incorporated Engineer (IEng) registration.

By structuring the first six work-based learning assignments as competency-based assessments with achieved/not yet achieved outcomes, the programme creates a supportive and low-risk learning environment in which Graduate Apprentices can develop and demonstrate the knowledge, skills, and professional behaviours required for successful completion of subsequent work-based learning submissions.

Application of the VARCS criteria enables an objective approach to the assessment of widely differing examples of each Graduate Apprentice's engineering knowledge, skills and behaviours with the sufficiency and level of evidence submitted are key determinants when confirming the graduate apprentice's level of engineering competence.

A potential limitation of the design of the initial 6 WBL assessments is that a minority of Graduate Apprentices, whose motivation is strongly influenced by the attainment of percentage grades, may invest only minimal effort in compiling their evidence portfolios, focusing instead on achieving a pass rather than producing their strongest possible submission. To counter this, the Programme Team highlight the risk of a minimal effort approach at the annual induction, reinforce that these 6 assignments are the foundations for a successful transition to the graded workbased learning assignments in later years and where necessary further discussions are held via the individual GA—Learning Adviser meetings and captured in the summative feedback. This strategy usually has the desired effect and typically ≥ 98% of the GAs complete Year 2 with a good understanding of how to prepare a successful WBL assignment.

The introduction of an ESD-focused dimension within the oral assessments has successfully prompted Graduate Apprentices to engage more critically with the legislative, ethical, environmental, and sustainability aspects of their workplace projects. Consequently, apprentices have demonstrated greater awareness of professional responsibilities, enhanced understanding of lifecycle thinking and sustainable resource management, and increased recognition of their potential role in supporting the development of future engineers through mentoring and STEM engagement activities.

In summary, the Graduate Apprenticeship EDM degree has supported the development of professionally competent engineers whilst while enhancing their confidence, effectiveness, and ability to make a meaningful contribution in their professional environment.

The portfolio of evidence mapped to UK SPEC for IEng has resulted in a fast-tracked pathway to professional registration for many of the GA EDM graduates as reflected in the findings presented by a strategic employer partner (May 2024 GA Employer Forum Presentation) and the publicly shared perceptions of many of the GA EDM alumni.

The external validity of the degree is evidenced by the achievements of our individual Graduate Apprentices, whose contributions and professional excellence have been recognised through a range of national awards and industry accolades.

Finally, the achievement of this Programme Team has been recognised internally via the recent nomination for a Faculty Engineering in Excellence Award and receipt of various University of Strathclyde Medal Awards.

Author Contributions

Susanne Boyle—Programme Director, Line Manager and Communicating Author. Colin Burns, Susan Walker and John Sweeney—Aacdemic Mentors for Graduate Apprenticeship degree and authors. Martin Cairns, Mark Charlesworth and Grant McConnachie—Learning Advisers for Graduate Apprenticeship degree and authors.

Acknowledgements

The authors acknowledge the leadership of Dr Andrew J. Mclaren (former Vice Dean Academic, Faculty of Engineering) both in the Chairing of the Technical Expert Group during the design of the national G(L)A Engineering: Design and Manufacture Framework and during the subsequent design of the academic curriculum of the Strathclyde degree. The authors acknowledge the support of the Year 2 Graduate Apprentice, and their employer, for consenting to the sharing of the EO203 Workbased Learning Assignment.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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