Design & Technology Education

David Morrison-Love

"Technology – the application of knowledge and skills to extend human capabilities and to help satisfy human needs and wants – has had profound effects on society." Education Scotland (2009)

While 'educational technology' (or ICT) can be employed within any subject area, Technology Education (or Design & Technology) is itself a discrete subject area wherein its concepts, knowledge, processes and outcomes, form a locus for pupils' learning. The earliest curricular incarnation of Design & Technology in Scotland appeared in the late 1800s when the Royal Society of Arts formalised the development of technical skills and knowledge in response to fast growing agricultural needs. Since that time, technology subjects have evolved to retain a valuable place within Scottish schools. This is not least insofar as they continue to foster knowledge, understanding, creativity, skills and dispositions related to real-world issues, processes and problems that are of considerable value to industry, business and society more widely. This evolution, however, has not been without challenge. Design & Technology is, in many senses, an educational construct with on-going efforts to characterise better and cohere its underlying epistemology (Morrison-Love, 2017). The complex nature of technology in different contexts—curricular and otherwise—results in variations in how it is viewed and understood as a subject. Encouragingly, historical perceptions of technology education as simply wood work, or as a less 'academic' pathway, appear to be lessening in Scotland.

The current suite of Scottish Design and Technology subjects can be characterised as drawing largely upon engineering and historically vocational roots (Doherty & Canavan, 2006). Collectively, they allow pupils to foster a wide range of skills and capacities in such things as: design thinking, research, concept development, manufacture and making, electronics, structures, control systems, graphics, computer modelling as well as technological effects and impacts. This builds technological capability and, within Curriculum for Excellence, is argued as essential for young people to embrace technological developments and play a major role in the global economy. Though not vocational by definition, these subjects offer unique and valuable points of departure for pupils into the world of work.

Design and Technology in the Scottish Curriculum Framework

Historical, teacher workforce, political, and socio-technological influences have, over time, shaped the accommodation of Design and Technology subjects in the Scottish Curriculum framework. Pupils can engage with technology subject content from early years, through national level courses to Higher and Advanced Higher. The structure of this content differs between educational phases with pupils able to study more specialised areas of technology through subject choice as they move from the broad general education into the senior phase. In 2016/17, the drafting of subject benchmark statements is an attempt to support progression better through the general phase and on into the more specialist areas of study. Broad General Education courses internally developed by departments necessarily introduce a spread of technological content and thinking but have, in the past, been recognised as disproportionately craft heavy by HMIe. Benchmarks for Design & Technology are exemplified around the areas of design and construction, uses of materials, graphical representation and application of engineering that articulate with content across senior phase subjects. Until recently, pupils who opt to specialise further in Design and Technology would have chosen one or two core technology options from Design & Manufacture, Graphic Communication, Engineering Science, or practical subjects in Woodworking, Metalworking and Electronics. Additional modules and skills for work courses that some departments offer could provide additional possibilities, with 'Design & Technology' also available as a discrete subject option (though only at National 3).

Though this is a significantly greater number of possible subjects than for any other school department, resources and capacity will typically allow for between two and four subjects to be offered with a range of SCQF levels. The landscape, however, has grown more complex with the emergence of new tensions around uptake. A slackening of the requirement that all schools run the Broad General Education up until the end of S3, and an increased flexibility in school timetabling, ultimately vary the points at which pupils undertake senior phase subjects. Simultaneously, a narrowing by schools of the number of subject choices at this transition point—for example, from eight to five—is growing in prevalence. This can amplify competition and make it more difficult for pupils to study more than one technology subject. In the first year of Design & Manufacture, there was a 47% drop in pupil uptake when compared with the number of pupils sitting Intermediate Product Design and Standard Grade Craft and Design in the final year they ran (McLaren et al, 2014).

Typically, Design & Technology is grouped in faculties alongside subjects such as Home Economics, Art & Design, PE and Computing. Departments of between two and six teachers deliver courses from within the four main subject streams typically found across Scottish Design & Technology departments. These are characterised in the following sections.

Graphic Communication Subjects

This subject centres on the development of visual interpretation, representation, reasoning, and literacy among learners. Here, pupils develop skills, knowledge and understanding in graphics and drawing types, conventions, equipment and technologies, graphic production and wider societal impacts. Historically, this subject evolved from 'Technical Drawing' which first appeared in the early 1970s alongside 'Building Drawing' as a core technical subject. Aspects of both were present within Standard Grade Graphic Communication, first introduced in 1992-3 academic year, and continue to be reflected in current courses. The addition of more presentation-based graphical approaches in Standard Grade marked a point of departure from the more engineering-influenced nature of its technical and building predecessors. Though these presentation approaches were procedural rather than artistic it was sometimes felt, by both teachers and pupils, that an artistic predisposition was nonetheless advantageous. The opportunity for pupils to learn using commercial CAD and 3D modelling software is a distinct strength and the subject continues to respond to advances in these.

Currently, pupils can study Graphic Communication from SCQF Levels 4 to 7. From National 4 to Higher, subjects are structured around '2D Graphics' and '3D and Pictorial Graphics'. In the first of these, learning focuses with increasing sophistication and demand on, for example, orthographic/geometric drawing, illustration and desktop publishing. The second encompasses pictorial drawings such as perspective sketches and isometric as well as 3D computer modelling using platforms such as Autodesk Inventor. In Advanced Higher, content is divided between units on commercial and visual media, and technical graphics with pupils able to extend their learning to include moving media.

Pedagogy involves individual, group, whole class approaches and process modelling targeted at developing procedural knowledge and visual interpretation. E-learning solutions are often employed in relation to 3D modelling which increasingly foster pupils' self-directed learning.

Assessment draws upon project work an assignment and exam, though the decision to remove manual drawing from the latter of these places a stronger emphasis on visual interpretation.

Engineering Science Subjects

For all of the same reasons articulated by de Vries (1996), Design & Technology in Scotland does not constitute applied science. This being said, Engineering Science reveals the closest overt proximity to science and maths of any of the subjects in this suite. With its roots tied to the 1960's subject 'Applied Mechanics', Engineering Science developed through a number of stages. In the 1970s, Applied Mechanics was replaced with Engineering Science which, to meet the shifting requirements of industry at that time, was considerably revised to form Technological Studies in 1988. It provided pupils the opportunity to engage in largely top-down, systems-driven problem solving in which solutions draw understanding from a number of areas such as electronics and structures. Pupils had to move beyond just learning about concepts, laws and principles, and functionally use them.

Curriculum for Excellence saw Technological Studies revised once again, re-adopting the name Engineering Science. This was partly in response to the University of Glasgow's 'Engineering the Future' project, which also gave rise to the STEM Central website. Available at SCQF levels 4-7, this subject draws heavily upon its predecessor. National 4, 5 and Higher courses comprise of units in 'Electronics and Control', 'Mechanisms and Structures' and 'Engineering Contexts and Challenges'. In the former two, pupils learn to analyse problem situations, simulate, develop, test and evaluate solutions. They build their understanding of analogue and digital electronics, and microprocessor control as well as material properties, mechanical and structural concepts such as moments and nodal analysis. In contrast to Technological Studies, the latter unit engages pupils more explicitly with what engineers do and the social and environmental impacts engineering has. At Advanced Higher level, this unit evolves to focus learning on the management and development of real-world engineering projects. With schools no longer required to use Basic Stamp, several are introducing pupils to more contemporary processor platforms such as Arduino.

The systems approach and comparatively structured problem-solving heuristics shape subject pedagogy with an emphasis on deductive approaches to learning. Whole class, group and individual approaches to fostering conceptual understanding are often set within project and problem-based contexts. Course assessment takes place through exams and pupil assignments.

Design & Manufacture Subjects

This subject evolved from a synthesis of Craft & Design and Product Design. The former of these, first introduced in 1985 (revised in 1992), evolved from what was Integrated Craft which, for the first time, introduced plastic work to woodwork and metalwork following the recommendations of the SEB's Curriculum Paper 10 in the early 1970's. Craft & Design further developed this in promoting a continuous rather than compartmentalised learning experience around designing and making that linked knowledge and understanding with project work. Notably popular with pupils, the subject provided opportunities for individualisation and a sense of ownership. Product Design, first introduced in 2004 at SCQF level 5 and above, offered pupils a strong insight into design and modern manufacturing, though was recognised in practice as having a greater emphasis on design over making in the sense that was often evident in Craft & Design. Challenges for some pupils lay with the level of English necessary for reasoning with complex design concepts.

Design & Manufacture, first introduced in 2012-13, offers pupils a similarly rich insight into the designed and made world but with more streamline curricular progression from SCQF Levels 4 to 7. Structured around 'Design', and 'Materials & Manufacture' from National 4 to Higher, this subject seeks to develop capacities in design thinking, problem solving, analysis, creativity, ideation, prototyping and evaluation. Pupils develop knowledge and understanding of design concepts, tools, processes and manufacture from 3D printing and laser cutting, through to larger scale industrial production technologies. Considerations of ethical, environmental and societal implications deepens understanding through setting decisions in a wider context. Units in Advanced Higher focus on product analysis, development and evolution allowing deeper examination of the historical and socio-technical influences on commercial products.

The varied nature of content engenders a range of whole class, group and individual learning and teaching approaches. These involving modelling, problem and project-based learning and design thinking. The most successful pedagogies explicate process over content and enable pupils to better transfer learning to individual project work whilst mitigate against fixation effects during idea generation.

Practical Subjects

In contrast to other subjects such as Design and Manufacture, this group of three subjects emphasises the development of practical skills in artefact manufacture over written understanding or design. Practical Woodworking and Practical Metalworking, available at SCQF levels 4 and 5, retain many of the more traditional hand and machining skills found in the technical subjects of the early 1970's. Practical Electronics differs insofar as it is structured around a design, fabricate and test process and has a nominal annual uptake of just over one hundred at National 5. At the same level, 4366 pupils were presented for Practical Woodwork in 2016 but, reflective of resourcing, demand and the profile of teacher expertise, the uptake of Practical Metalwork is normally around one quarter of this. These subjects are distinct in that they are not available beyond National 5 and are internally assessed.

Practical Woodworking and Metalworking are structured around three units. Success requires significant levels of practical problem solving, visual interpretation, and resilience in realising high quality material artefacts from construction drawings. In Practical Woodworking, pupils develop skills in frame and carcase construction, machining and finishing. Permeating skills include measuring marking out and cutting with an expectation that pupils work towards achieving practical tolerances of +/- 1mm. This is also true of Practical Metalworking where pupils develop bench skills, machining, methods of fabrication and thermal joining. There has been an erroneous tendency to associate the practical nature of these subjects with a lower level of challenge, but this fails to recognise that challenge in learning exists in multiple forms. Many pupils find these subjects to be highly demanding due to the expected level of craftsmanship and sustained levels of concentration required.

Modelling and cognitive apprenticeship-style pedagogies dominate these subjects with significant demand on the classroom teacher to manage pupils and resources in a way that simultaneously maximises learning, health and safety. Pupils' grades are based on their value-added project.

Recent Developments in Design & Technology

Over the last few years, significant change in Design & Technology has been felt by departments across Scotland with some of the most notable in Design & Manufacture and Graphic Communication. Teachers recently welcomed a dramatic reduction by the SQA in

the number of assessment standards in Design & Manufacture from over thirty to just eighteen. Combined with new progression thresholds in all technology subjects, this eased both evidence gathering and better aligned the subject with the philosophy of Curriculum for Excellence. With subject content, a less linear conceptualisation of design activity enhances authenticity, though difficulty remains for many pupils in distinguishing between analytical and evaluative processes. In Graphic Communication, manual drawing with instruments was removed from SQA examinations. This prompted a tectonic shift in the nature of assessment for this subject which is now characterised far more by visual interpretation and reasoning. Pupils subsequently require quite different cognitive skills and changes to subject pedagogy for which teachers have received little support. Further change is likely following the government's decision to remove the requirement for unit assessments for all subjects.

Moving Forward

Design and Technology has made a robust contribution to the education of Scottish schoolchildren with continued opportunities and challenges. There are exciting opportunities for innovation with new and emerging digital technologies, but access to facilities such as laser cutting, 3D printing and high-end computing—whilst greater than ever—remains inconsistent across Scotland. Though design and technology provides a tremendous context for interdisciplinary learning, this sits largely untapped with Scotland yet to embrace more integrative approaches to STEM.

Finally, continued efforts to encourage highly capable teachers into Design and Technology are essential. Protection of disciplinary expertise forms a critical part of this within a growing culture of 'genericisation' in Initial Teacher Education. Notably, of those students at the University of Glasgow working towards a teaching career in Design and Technology, around 58% are female. This will grow the number of role models in an important, but still male-dominated, subject area.

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