14
Facilitating
The role of learning environments in technology education curricula

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Introduction

This chapter explores how specialist classrooms in technology education *facilitate* learning and are an essential aspect of the subject's signature pedagogy. When considering signature pedagogies in professional learning, Shulman (2005) reflected on the relationship between disciplinary learning, specialist teachers and learning environments. When describing design studios, he commented on the difference in the learning environments and activities compared to engineering workshops in the same faculty. Both these disciplines are included within various technology curricula around the world. The 'classroom' alongside the actions of the teacher mediates how the learners participate in either collaborative or independent, experimental, or creative work. When discussing the learning environment in this chapter, 'classroom' will be used as a general term to describe a range of specialist technology education spaces within a school context. In some technology learning environments, there is an obvious focal point, such as a demonstration station, whiteboard, or screen, which infers a more teacher-led approach, whereas others are focused more on group or individual work. Furthermore, so learning environments are more flexible, being adapted by the teacher to suit the learning activity. For example, the work benches a multimedia workshop designed for making in a range of materials may be adapted for working in either wood or metal vices, or drawing board being used for design or graphic work to cover the nicks and dents caused by working with materials.

The very nature of specialist learning environments enable certain activities, but also inhibit or limit others. For example, a typical school teaching kitchen is arranged in pods or bays for groups of two to four learners, with access to a cooker and utensils. However, these environments do not lend themselves to group discussion or written work, as stools are not desirable for practical and safety reasons, and worksurfaces tend to be over cupboards or drawers (i.e., no knee room). Therefore, many technology 'classrooms' are hybrid spaces, adapted for multiple activities and materials.

Key Issues

There are a range of factors for the technology educator to consider when facilitating learning in technology classrooms. These include how classroom activities are managed, as well as how resources and equipment are accessed and used by learners. For example, the location of portable electrical equipment affects how learners move around the classroom, creating potential ‘bottlenecks’ that restrict access to certain parts of the room, which affects both the efficiency and safety of the space. In this section of the chapter, we will explore aspects of managing the Technology Education environment, resources, risk and classroom.

Environment Management

The classroom environments for technology education are varied and complex, including disciplinary areas as diverse as electronics, engineering, food, product design, robotics, textiles and graphics. Each discipline has its own requirements for equipment, including tools (hand, machine and digital) and furniture (tables, benches, stools), which affect how the spaces are laid out and used. In an ideal world, technology classrooms would be designed in consultation with technology educators. However, even where this is the case and spaces are well designed, changes in technology and curriculum can render equipment obsolete. There is often a reticence to decommission equipment on the grounds of expense or on the off chance that it might be useful. An example of this in the UK is the presence of heat treatment areas in many Design & Technology (D&T) workshops, with machines for forging, brazing and casting, with the associated partitions, ventilation and gas supplies. These facilities have largely become redundant in many departments, unless they offer engineering course with traditional metal work skills. So typically, these facilities take of space for most of the year.

Technology education plays an important role in developing students’ practical skills and creativity. This often involves the use of specialist equipment to realise design ideas or apply technological knowledge. The history of many technology curricula is inextricably linked with industrial arts and crafts, with students being prepared for future life and work. Therefore, some degree of risks is not only to be expected, but encouraged in order for them to become more confident assessing and managing risks for themselves. The core health and safety training standards from the D&T Association (D&TA), the subject association for teachers of design and technology in the UK, describes three levels of supervision (Table 1). The level of supervision required assumes the teacher’s intimate knowledge of both subject content and the classroom environment, in addition to the capability of students. The latter of which is influenced by factors including age related expectations, prior experience and individual students learning needs. Therefore, it is essential for the technology teacher to work within and adapt their classrooms, balancing a variety of often competing requirements. This is an important, an often-overlooked aspect of pedagogical content knowledge (PCK) for technology teachers.

Technicians also play a vital role in both maintaining teaching spaces and supporting learning, in collaboration with teachers. Unlike other adults in the classroom, such as teaching/learning assistants, technicians have technical knowledge and expertise, which can be invaluable activities requiring one-to-one supervision. The enables the technology teacher to plan for a whole class and delegate responsibility to a technician, facilitating multiple activities in a lesson and enabling some students to access higher risk equipment safely.

Table 1 Levels of Supervision (D&TA, 2014, p. 6)

Supervision	**Description**
General class	“…suitable for low risk activities such as design or research work. General workshop supervision means that the teacher has an overall view of the whole

	class and is able to monitor the actions of all learners. The shape of the room (pillars, 'L' shaped rooms etc.) is an important factor and teachers should ensure that layout of the desks facilitates effective monitoring."
Close class	"…should be employed where medium risk activities are being carried out. Close class supervision involves the teacher adopting a position in the room which will enable them to intervene quickly in any of the activities should it become necessary. For instance many food rooms are laid out in bays. The teacher supervising practical food lessons should be able to reach each bay without having to negotiate desks or other obstructions."
One to one	"…reserved for high risk operations and requires the teacher to give total concentration on one learner. This means that they are unable to provide either close class supervision or general class supervision. Talking to and discussing individual learner's work does not constitute a one to one situation as the teacher should use well practised teaching techniques such as scanning and listening to monitor the group."

Resource Management

In the context of 'close class' supervision, the location of resources (including equipment and materials) is a key concern for the technology teacher. Some items of equipment will be fixed/permanent (e.g., drilling machines, sinks, ovens, etc.), whereas others will be movable/temporary (e.g., sewing machines, soldering irons, vacuum formers, etc.),). However, there is an increasing interest in developing standards for trolley mounted machinery, that would previously been required to be permanently installed, such as bandsaws and centre lathes mounted on trolleys (e.g. DfES, 2004). The benefits include being able to create truly multimedia learning environments, which are adaptable to activities students are currently engaged with. This also helps to avoid distraction or sending out mixed messages about the sorts of tasks students are going to be involved with in a particular lesson. For example, undertaking user-centred design activities in a workshop fitted for heavy duty wood or metal work may bias learners and limit their creativity to the materials and process on display. Challenges also need to be overcome when using moveable machinery, such as the temporary location within the classroom, storage when not in use, lockability of wheels to prevent movement during use, local exhaust and ventilation (LEV) of dust and access to an appropriate isolatable power supplies (linked to an emergency 'stop' button).

A key consideration for the location of permanent and temporary workstations is that of 'bottlenecks', i.e., areas where there is a high demand for and low access to items. The location of permanent workstation is outside of the control of most technology teacher, but thy should consider how students access equipment, such as:

- minimising queuing using sign-up sheets or allocating individual/group access;
- planning for groups to be working on different tasks or sequences;
- increasing the number of a given item of equipment available to students (note: this is easier to achieve with hand than with machine tools);
- designing learning activities that reduce the need to routinely access machine tools;

Bottlenecks are also common for temporary workstations, with the same restrictions and possible solutions listed above. However, the technology teacher has more control over where the workstation is located and how students access equipment. An obvious solution is to have sufficient items for all students to use simultaneously, but this will have significant implications for the cost and storage of resource - not to mention the subconscious messages that this sends to student on what is deemed to be important. The reality for most technology teachers is that they will balance limited budgets and space and manage learning environments through careful planning. Therefore, the location of temporary workstations should plan for close class supervision, with easy access for the teacher (or another adult in the classroom, such as a technician or teaching assistant) in case of emergency. A key skill for the technology teacher working in a practical environment is visually and aurally scanning the room at regular intervals for change and possible hazards, keeping all risky activities in full view - i.e., avoid locating yourself in positions where your back is turned to activities or your ability to monitor and respond are limited.

In addition to the issues relating to equipment, similar issues arise for the access to and distribution of learning materials, be they the materials or components that students are using in design and make activities or construction kits for mechanical, electronic, or pneumatic modelling. There are three different approaches that may be adopted, each having benefits and limitations: bins, boxes, or kits (Table 2).

Table 2 Storage of materials and components

Approach	**Description**	**Benefits**	**Limitations**
Storage bins	Typically, component bins (for small items such as screws, electronic components, zippers, etc.) are wall mounted drawer units, but can also be mounded on trolleys. Stock materials would normally be kept in storeroom.	Efficient use of space, with commonly used components readily available. Promotes student autonomy and selection of correct components.	Difficult to monitor usage and may lead to waste if poorly managed and supervised. Similar 'bottleneck' issues as discussed above.
Project boxes	Carefully planned projects will typically use a definable list of materials and components, which can be packaged into boxes for a class, by the teacher or technician.	Efficient use of materials and components. Easy to plan and monitor, when linked to a unit of work.	Limits autonomy, creativity and choice of materials and components. Needs to take waste and damage into account. Similar 'bottleneck' issues as discussed above.
Student kits	Individual project or task kits of parts (materials and components), which can either be bought in or assembled in-house. Typically supplied/deployed to students at their tables, but the teacher or technician.	Reduces movement to access resources. Efficient use of materials and components. Easy to plan and monitor, when linked to a unit of work.	Limits autonomy, creativity and choice of materials and components. Does not take waste and damage into account.

Depending on the learning intentions for a project, the technology teacher must decide on whether to adopt a more restrictive approach where resources are provided for students where they are sitting (i.e., student kits) or a more expansive one with them selecting and retrieving them for themselves (e.g., storage bins). Consideration of an expansive-restrictive continuum of pedagogical approaches (McLain, 2021) will balance the inherent limitations of any technology classroom with the learning intentions for a specific class.

Risk Education Versus Risk Management

The chapter on Safety, Risk and Learning by Eila Lindfors (Section 3) outlines the issues around risk management and education in more depth. However, any discussion on facilitating technology education should consider the implications for how students learn to manage risk effectively (risk education) and how the technology teacher manages a safe learning environment (risk management), ensuring that their classrooms are well designed and maintained, lessons are well planned and delivered. Effective classroom management ensures that the tensions between risk education (i.e., developing awareness and giving students the opportunity to management risk for themselves) and risk management (i.e. undertaking risk assessments as part of curriculum and lesson planning); involving the use of pre-emptive strategies, such as controlling risks to minimise potential harm and making students aware of hazards and safe working practices, alongside reactive behaviour management strategies. In the UK, the Health and Safety Executive (HSE) recommend five steps to risk assessment to be undertake by a 'competent' person: identify hazards, assess risks, control risks, record findings and review controls. Local and national authorities provide contextualized guidance on what this means for the technology classroom (in this case Design & Technology or D&T), including a British Standard code of practice (BSI, 2021). This fulfils the *risk management* aspect of the teacher of technology's role, but making students aware of hazards, risks and controls enables them to develop autonomy, capability, and competence (*risk education*). National organisations supporting technology educators (e.g., the Design and Technology Association in England and the International Technology and Engineering Educators Association in the USA) will typically offer guidance of risk management, including safe working practices and risk assessment. It is also common for employing schools to ensure that suitable health and safety training is in place for teachers (D&TA, 2021).

Classroom Management

A well-managed technology lesson, and classroom, should (a) engage learners in meaningful activities, (b) effectively manage the learning environment and resources, and (c) put control measures in place to manage potential risk. Therefore, a well-planned (and delivered) lesson should require minimal behaviour management. That is not to say that reactive behaviour management techniques are never required in technology education lessons, but rather the goal should be to 'design out' the need for routine use of these strategies. A key to doing this is planning engaging, active, and applied learning activities. Wubbels (2011) discusses international perspectives on classroom management, suggesting six approaches. Table 3 outlines examples and a critique if each approach in a Technology Education context. Typically, classroom management in the Technology Education classroom focuses on safe and efficient working practices and behaviours, encouraging students work in a cooperative and mature manner.

Table 3 Six approaches to classroom management

Approach	Technology Education Examples	Critique
Behavioural	Positive reinforcement with rewards of following TE classroom safety rules, and negative reinforcement by either removing a student from the space or ceasing the activity.	Whilst it is important to stop a risky activity quickly to avoid physical harm, removing the learning opportunity from the student(s) negatively impacts on their learning.
Internal control	Explaining the rationale for TE classroom rules and routines, and engaging students as a community of learners working together in a responsible manner.	This approach is relational and depends on a degree of reciprocal trust and respect between the teacher and the students, which takes time to develop.
Ecological	Considering the TE classroom as an active environment, planning for efficient movement when students are unseated, including the location of equipment/workstations to minimise bottlenecks, etc.	Thus is a common approach in workshop environments, where a high degree of teacher control is necessary to ensure safety, but relies on students' compliance and willing participation.
Discourse centred	This might look like the ecological approach, but focus more on engaging students in agreeing, setting, and maintaining rules and routines in the TE classroom, through classroom discussion and student voice.	Like internal control, this approach relies on mutual respect and strong relationships between the students and teacher. It can be time consuming both to develop the culture and enact in the classroom.
Curricular	TE projects and tasks are carefully design and planned to motivate and enthuse students, and indirectly reduce potential misbehaviour, considering their capability and interests.	Where the focus is heavily on students being kept active, rather than engaged in meaningful learning, this approach can lack depth and hinder progression.
Interpersonal	The TE teacher adopts a level of control with the class, between dominant and cooperative behaviour, depending on the situation, such as using high level of control where the risk is high/immediate.	This approach relies on the teacher to be able to quickly assess the situation (read the room) and switch between one persona and another (like an actor), and tends to come with experience.

Physical Learning Environments

Disciplinary learning in technology curricula has been historically mediated by the bodies of knowledge related to the materials used in the traditional crafts; from which they evolved in the late 20th Century. However, these origins both inform and inhibit curriculum development. Existing facilities in schools are adapted and used to deliver now content and activities. New facilities quickly become obsolete as technology and society change. So, a critical question for technology educators is: how does my 'classroom' enable and disable the delivery of a modern and authentic technology education?

In the following sections, we will explore the range of spaces that are common to various technology education curricula. You will notice a degree of overlap between the descriptions and many of the labels adopted may signal the values of the teachers and departments. For example, the term studio may be adopted to indicate that the intention of the space is orient towards a more open and design led curriculum, as opposed to a more practical and technical one where workshop may be the term of choice. Names can matter, and a change of terminology can signal a change of practice for students, teachers and senior leaders.

Don Norman (2013) talks about the affordances and signifiers of products, concepts that also relate to the design of technology classrooms. The affordances of technology classrooms are the actions that they make possible. So, for example, the equipment and machinery in metalwork classroom enable the shaping of objects in metal, etcetera. The same equipment and machinery (as well as the arrangement of furniture) are also signifiers, indicating to users (students) how the room is to be used. For students new to the space, the discoverability of the classroom's function will be limited, but for the more experienced who recognise and are able to use the facilities the signifiers will shape their expectations for the activities to be undertake. Poorly designed classrooms, including those that are being used for functions beyond the space's original intentions, are undiscoverable and confusing for learners. For example, where a teacher is wanting students to ideate and prototype solutions with the most appropriate materials and components, being in a classroom design for specific materials/technologies (e.g., electronics, control, engineering, food, metal, pneumatics, robotics, textiles, wood, etc.) can send unintended messages that may limit creativity and innovation. Therefore, the teacher of technology should be aware of the benefits and limitations of their classrooms when planning for learning.

Workshops

The word 'workshop' is associated with spaces where things are made or repaired. Other cultures use the term *atelier*, which is derived from the Middle French *astelier* (meaning woodpile) and is associated with artists' or designers' studios/workrooms. There term workshop implies action and doing and has more recently been adopted for more cerebral and collaborative sessions in education and business. However, in the context of this chapter, we are concerned with the practical spaces used in technology education classrooms, where students typically engage with making, manufacturing, fabrication and assembly of products and/or systems. These spaces are often defined by the material technologies being used (e.g., woodwork or metalwork), but in many schools a multimedia approach has been adopted - particularly where the curriculum is orient towards craft and design, as opposed to vocational and technical (e.g., engineering, manufacture, etc.). Workshops tend to be arranged and constrained by the equipment and machinery, which does not necessarily make them the most pedagogically idea environments. There are always compromises between the technical and pedagogical requirements for technology workshops, as the optimal arraignment of equipment may not be the most conducive for effective classroom management.

Studios
Whereas the label workshop infers a common aim and intent to the activities within their walls, the label studio is associated with more autonomous and self-directed activity. For example, in university art and design buildings, students often have an individual studio space assigned for project work. Studios are more common where the curriculum is more design oriented and where project-based learning is a signature pedagogy. They tend to be more open plan in layout. In schools, these spaces typically have large tables for collaboration and design work. In some cases, such as in classrooms where the focus is on textiles the tables may be higher to facilitate standing rather than sitting. Or in the case of graphics or computer-aided design (CAD), the classroom may be closer in layout to an IT suite. However, in this case the arrangement of computer terminals also signals how the space is intended to be used. For example, a more didactic space may have the stations in rows facing the instructor, around the perimeter with collaborative / non-computer mediated activities in the centre, or in clusters where team / group work is encouraged.

Laboratories
The label 'laboratory' has connotations of scientific experimentation and is typically used for activities involving systems and control, including electronics, mechanisms, and pneumatics. Like with IT suites, the orientation may be in rows facing the instructor or in clusters, as access to workbenches with electrical power supplies for electronics or compressed air for pneumatics. However, the use of ceiling mounted, retractable power supplies can facilitate table-based work (e.g., the use of power supplies or soldering irons) in more general or multimedia spaces.

Kitchens
Kitchen or food preparation areas are possibly the most specific of technology education learning environments, in part due to hygiene restrictions. In the school environment, pedagogical kitchen is typically arranged in pods or bays, where students share facilities, such as a cooking hobs, ovens, and utensils. The most common arrangement has a teaching station at the front of the classroom, with a demonstration station facing the class. Others, however, locate the demonstration in the centre, which can also be raised to enable the instructor to monitor the room. There are benefits and limitations to both arrangements, but the latter does not afford a view of the whole room at a glance, which has implications for classroom management.

Work-based Learning Environments
Whilst technology education's impact and relevance are beyond narrowly vocational aims, in many jurisdictions - i.e., it is more than training children and young people (CYO) for jobs – it plays an undeniable role in the preparation of CYP for the world of work; particularly in technologically advanced (and advancing) societies. We live in a world where work is not only a necessity for individuals to survive and thrive or plays a vital role in our personal and society good, but as global societies we face challenges that affect the future of mankind.

These so-called wicked problems are not just theoretical, but threaten the sustainability of the human race and the planet as we know it. Technology education plays an important role in preparing future workers and leaders to act with integrity. Therefore, work-related, and work-based learning environments will be a factor in most technology curricula as children progress through primary, secondary, and tertiary education into the workplace.

Typical ways in which this happens in technology curricula are through progressive engagement with work environments with activities including industrial: simulation, visits and placements. Industrial referring to a wide range of sectors from engineering and manufacture to creative and design.

Simulation

Where technology curricula have a focus on technical knowledge for industrial contexts, such as manufacturing and engineering, the typical technology classroom is not equipped for learning through project-based methods (e.g., designing and making). Common example of this are energy generation/capture, communication, robotics, and production lines. There are three ways that specific work-based learning environments can be simulated in the school setting. The *first* is by using one of the many learning systems available on the market, which provide integrated learning systems that can be tailored to specific technological concepts and industrial contexts. These systems are often computer-based, linking with hardware, and focus on developing technological knowledge and task-based, rather than project-based, learning. This is the most expensive option for industrial simulation. The *second* approach is to use simulation software. Common examples focus on schematic design for electronic circuits or pneumatic systems, and can be a more cost effective and flexible, only requiring computer access. A third option is to use videos of industrial process, which can be freely available online, but require time to find and quality assure. However, they offer the flexibility for students to access them both during and outside of lessons. The fourth option is more modelling than simulation, with classroom-based activities being used to simulate principles, rather than a specific process. This can be done by setting up a production line to assemble a product, such as a Lego model, with students working in groups, each member undertaking a different assembly stage. This can then be compared with the time for one person to assemble a complete project, to illustrate the advantages of production lines.

Visits

Learning outside of the classroom in technology can enable students to contextualise their learning and get a better understanding of possible career opportunities. Clearly there is insufficient time in the curriculum to plan visits that represent all the possible opportunities; from design through to manufacture. However, a well-designed educational visit to a local university, factory or design studio can open student’s minds to possibilities and bring them face-to-face with real designers, engineers and technologists. Different ways to incorporate an educational visit into a technology curriculum including plan a visit to:

- a factory that used processes that are relevant to prototypes that students have been designing and making as part of a lower school project;
- a business undertaking procedures related to a topic that is about to be studied, such as the sustainable use of materials and the impact on the environment;

- a venue or location to be used a context for a design project, such as a kindergarten or retirement home, to develop students' empathy and understanding of challenges;
- a museum with exhibits of technologies from past eras to promote discussion and exploration of the impact of technology on society, and vice versa;

Effective education visits will plan for learning activities:
- prior to the visit to set the context and get students thinking about the learning intentions;
- during the visit to focus students on the key learning intentions and how it links to their wider learning in school;
- after the visit to consolidate student's learning and use the experience to enhance their classroom learning;

Placements
Whilst technology education is more than a vocational subject, preparation for future careers is a significant element of its history, as well as current expression in many international curricula. Therefore, work placements are a significant element of many post-16 qualifications.

Virtual Learning Environments

Educational technology has made it possible for much of the learning traditional taught face-to-face to be facilitated online. However, the hands-on and practical nature of technology education (particularly versions informed by the designing and making paradigm) makes it difficult to conceive of a purely online curriculum model, particularly where activity and project-based learning is a core paradigm. However, online technologies do afford opportunities that may not be readily available in the typical technology classroom. Such as, accessing online content (videos, animations, simulations, etc.) or live communication (virtual industrial visits, consultations with experts, project management, etc.).

Advances in digital technologies has also led to advancements in computer aided design and manufacture (CADCAM), computer integrated manufacture (CIM), rapid prototyping (RP), and finite element analysis (FEA); with the recent emergence of cloud-based software, such as Autodesk's TinkerCAD and PTC's Onshape, which promises to make CAD ubiquitous, increasingly collaborative, and free from the restraints of operating systems. These technologies provide opportunities for face-to-face, online, and blended models of teaching - blended learning being a combination of face-to-face and online.

Online and Blended Learning
Whilst technology educators in remote and rural areas, such as parts of Canada and Australia, are used to elements distance learning (going back to pre-internet times), the COVID-19 pandemic of 2020 and 2021 has brought a new challenge to us all. Fortunately, advances in online technologies afford schooling and education a wider repertoire of approaches to distance learning. However, during lockdown, limited or no access to specialist technology education facilities, equipment and resources has rendered much of the technology

curriculum unfeasible, particularly those working within practical or designing and making paradigms. Furthermore, data from the Office of National Statistics in the UK, indicates that the teaching of arts based subjects (including design and technology) was disproportional affected by remote teaching than other STEM or humanities subjects; and unlike these subjects teaching did not improve significantly over time (O'Malley, 2021). The very nature of a technology curriculum as experiential over knowledge-based, presented technology teachers with seemingly insurmountable challenge. So, the question is: Can technology be taught effectively online?

In answer to that polarising question, it depends on whether the curriculum model is predicated on knowing about technologies (technological knowledge) or knowing how to use technologies (technological capability). The reality is that most curricula will incorporate elements of both, and it is argued that domain specific knowledge is a prerequisite for meaningful skill development (Ericsson & Pool, 2016), particularly with children in early years and primary education (Hirsh, 2018). Technology curricula that are focused on activity and artefacts are typically built around project-based learning, which focus on designing, making and evaluating technological products, systems and environments. Whereas those focused on technological knowledge may focus more on learning about facts, principles and processes. Mitcham's modes of the manifestation of technology (1994) offers a third way of thinking about technology, volition, which is concerned with philosophy focusing on "mind, motivation and intentionality" (McLain, Irving-Bell, Wooff, & Morrison-Love, 2019, p. 474). This aspect of technology education is gain an increased level of focus in the form or critiquing (Williams & Stables, 2017).

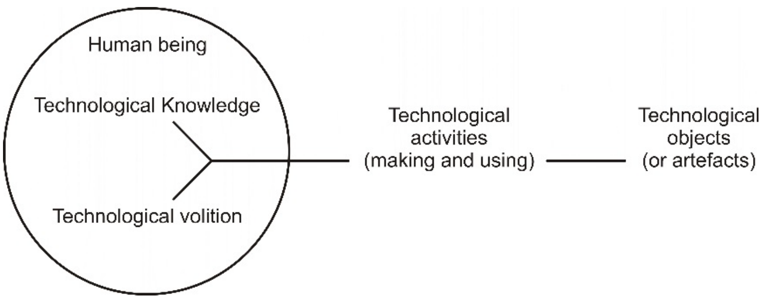

Figure 1 Mitcham's (1994, p. 160) modes of the manifestation of technology

Broadly speaking, Mitcham's diagram describing the relationships between the four modes (Figure 1) locates technological knowledge and volition within the human being, with activities and objects outside. There is potential for the 'human' elements to be taught without the level of resources or facilities required for engaging with technology activities and producing technological objects. Therefore, these aspects of a technology curriculum lend themselves to being taught remotely or online, as they do not require the same level of resourcing or supervision and could be completed in the home or a non-specialist space. However, to begin thinking about making and using of technologies or the creating of artefacts confronts the technology teacher with the challenge of socio-economic status (SES) and digital poverty, which risk widening the attainment gap between the high and low SES students. This can be overcome by providing resource packs or kits for students to use at home, but will inevitably exclude the use of specialist equipment or potentially hazardous materials - both of which are a key feature of many curricula and play an important role in risk education. Therefore, whilst the inclusion of a blended approach to teaching technology could enhance the learning experience, it will inevitably reduce the amount of time spent in specialist facilities, using specialist tools and equipment. This may not be a bad thing, particularly as technology, society and the workplace change and evolve, but it will require a paradigm shift in the way that we conceive technology education. Furthermore, a solely online technology education radically alters the very nature of the subject and is arguably incompatible with how the subject is taught, in its many different iterations, around the world.

Active Blended Learning

Active blended learning (ABL) is an approach that has been developed by the university of Northampton (UK) during the COVID-19 pandemic in 2020/21, and focuses on context rather than content for online symmetric learning - symmetric being where the students and/or teacher are working on a task/activity during the same time period. Content is seen as being primarily delivered asymmetrically using a variety of media including text, audio-visual and audio only based resources - i.e., accessible by students at any time before or after a 'symmetric' session, independently from the teacher - or in a symmetric face-to-face setting. Therefore, when using an ABL approach in technology education, the teacher should consider what content can safely and meaningfully be delivered online without the need for supervision and specialist resources. Emerging evidence from this very recent (at the time if writing) period in history underlines the importance of the unplanned student/student and student/teacher interactions afforded by face-to-face teaching for both students' understanding and wellbeing; as well as increasing attainment gaps in reading and mathematics between high and low SES students. This suggests that very careful consideration should be given to how much online learning is in the best interest of students from less advantaged homes but, where it does, it should focus on context and relationship building for symmetric learning.

Technology Enhanced Learning

Those outside of the field are often confused between technology education and educational technology. The two are very different, one being a subject or discipline, the other a cross-curricular suite of pedagogical approaches and products, that include *hardware* - e.g., interactive whiteboards, visualisers, etc. - and *software* - e.g., virtual learning environments (VLE), quick response (QR) codes, augmented reality (AR), virtual reality (VR), etc. Clearly, technology education uses technologies, such as machines and equipment (hardware) and CAD programs (software), but these are primarily elements of the curriculum content, rather than vehicles to support learning; or technology enhanced learning (TEL). Examples of TEL in technology education include using:

- visualisers or live video feeds to support the demonstration of fine motor skills or detailed work;
- QR codes or VR to link to online information, guidance for tools and equipment (e.g., procedures and/or safety), virtual visits (e.g., museums, galleries, industry, etc.), accessible in the classroom using digital devices;

- Recorded audio-visual materials to prepare students for a new topic, support direct instruction or consolidate learning;

Summary

This chapter has explored how the learning environment facilitates learning in Technology Education, emphasising how the specialist nature of these spaces are integral to its signature pedagogies. The facilities required for teaching spaces are directly related to the role and nature of the technology curriculum in a school. And where the curriculum changes, technology classrooms need to be update, modernised, and adapted to be fit for purpose. The key issues for the technology teacher planning for teaching in specialist facilities involved managing the environment, resources, students, and risks. Classroom management, in this case, is more complex and comprehensive than the use of behaviour management techniques in response control misbehaviour. Effective classroom management in Technology Education is proactive, using strategies including curriculum design, classroom layout and arrangement of the equipment and the access to learning resources, including materials and components for project-based learning. Effective technology teachers must have strong subject knowledge, as well as experience and competence using the techniques, tools, equipment, and facilities that the students will experience in lessons. They need to understand what students are capable of and how best to supervise them during practical work. This includes liaising the other adults in the classroom, such as technicians, and planning for how they will support students, both inside and outside of lesson time.

There are a wide range of different types of technology classroom, optimised for working with different materials (e.g., food, metal, plastic, textiles, wood, etc.) and technologies (e.g., electronics, mechanisms, pneumatics, robotics, etc.). These are physical spaces, which are normally located in the school building(s). However, due to the nature of Technology Education and its relationship with vocational and technical education in some countries, learning environments can also be offsite, such as industrial settings (e.g., factories, laboratories, workshops, etc.) or technical education establishments. School students can access these spaces through education visits, planned and managed by the teacher, or for older students, through placements where they can experience work-based learning. Engaging with these highly specialised facilities outside of the school, can support students understanding of how the technology curriculum applies in the real world. However, virtual visits and simulation can provide a more cost effective and safer alternative, especially with the development of virtual and augmented reality technologies. Specialist learning environments are essential facilities of effective and authentic learning in Technology Education.

Questions for reflection

1. What makes Technology Education ‘classrooms’ different to traditional learning environments?
2. What factors influence how teachers of technology plan for teaching in specialist learning environments?

3. What is the relationship between classroom management and behaviour management in Technology Education?
4. What is the role of virtual learning in a practical and creative subjects like Technology Education?

References

BSI. (2021). *BS 4163:2021 Health and safety for design and technology in educational and similar establishments (Code of Practice)*. London: British Standards Institution.

D&TA. (2014). Core Level Training Standards (Secondary). In *Health and Safety Training in Design and Technology*. Banbury, UK: Design and Technology Association.

D&TA. (2021). *Health and Safety* [webpage]. Retrieved from https://www.data.org.uk/for-education/health-and-safety/ [accessed 14/01/2022]

DfES. (2004). *Building Bulletin 81 Design and technology accommodation in secondary schools: a design guide*. Norwich, UK: The Stationery Office Retrieved from http://science.cleapss.org.uk/Resource/Building-Bulletin-81-Design-Technology.pdf [accessed 14/01/2022]

Ericsson, A., & Pool, R. (2016). *Peak: Secrets from the New Science of Expertise*. London: Vintage.

Hirsh, E. D. (2018). *Why Knowledge Matters: Rescuing Our Children from Failed Educational Theories*. Cambridge, USA: Harvard Educational Press.

McLain, M. (2021). Key pedagogies in design and technology. In A. Hardy (Ed.), *Learning to Teach Design and Technology in the Secondary School* (4 ed.). Abingdon, UK: Routledge.

McLain, M., Irving-Bell, D., Wooff, D., & Morrison-Love, D. (2019). How technology makes us human: cultural and historical roots for design and technology education. *The Curriculum Journal*, 30(4), 464-483. https://doi.org/10.1080/09585176.2019.1649163

Mitcham, C. (1994*). Thinking through technology: a path between engineering and philosophy*. Chicago: The University of Chicago Press.

Norman, D. (2013). *The Design of Everyday Things, revised and expanded edition* (2 ed.). Cambridge, MA: MIT Press.

O'Malley, J. (2021). Why arts subjects were hit so hard in the pandemic. *TES Magazine*. Retrieved from https://www.tes.com/magazine/analysis/general/why-arts-subjects-were-hit-so-hard-pandemic [accessed 14/01/2022]

Shulman, L. S. (2005). Signature Pedagogies in the Professions. *Daedalus*, 134(3), 8. http://dx.doi.org/10.1162/0011526054622015

Williams, P. J., & Stables, K. (2017). *Critique in Design and Technology Education*. Singapore: Springer.

Wubbels, T. (2011). An international perspective on classroom management: what should prospective teachers learn? *Teaching Education*, 22(2), 113-131. https://doi.org/10.1080/10476210.2011.567838

BSI. (2021). *BS 4163:2021 Health and safety for design and technology in educational and similar establishments (Code of Practice)*. London: British Standards Institution.
D&TA. (2014). Core Level Training Standards (Secondary). In *Health and Safety Training in Design and Technology*. Banbury, UK: Design and Technology Association.
D&TA. (2021). *Health and Safety*. Retrieved from https://www.data.org.uk/for-education/health-and-safety/
DfES. (2004). *Building Bulletin 81 Design and technology accommodation in secondary schools: a design guide*. Norwich, UK: The Stationery Office Retrieved from http://science.cleapss.org.uk/Resource/Building-Bulletin-81-Design-Technology.pdf
Ericsson, A., & Pool, R. (2016). *Peak: Secrets from the New Science of Expertise*. London: Vintage.
Hirsh, E. D. (2018). *Why Knowledge Matters: Rescuing Our Children from Failed Educational Theories*. Cambridge, USA: Harvard Educational Press.
McLain, M. (2021). Key pedagogies in design and technology. In A. Hardy (Ed.), *Learning to Teach Design and Technology in the Secondary School* (4 ed.). Abingdon, UK: Routledge.
McLain, M., Irving-Bell, D., Wooff, D., & Morrison-Love, D. (2019). How technology makes us human: cultural and historical roots for design and technology education. *Curriculum Journal*. doi:10.1080/09585176.2019.1649163
Mitcham, C. (1994). *Thinking through technology: a path between engineering and philosophy*. Chicago: The University of Chicago Press.
Norman, D. (2013). *The Design of Everyday Things, revised and expanded edition* (2 ed.). Cambridge, MA: MIT Press.
O'Malley, J. (2021). Why arts subjects were hit so hard in the pandemic. *TES Magazine*. Retrieved from https://www.tes.com/magazine/analysis/general/why-arts-subjects-were-hit-so-hard-pandemic
Shulman, L. S. (2005). Signature Pedagogies in the Professions. *Daedalus, 134*(3), 8. doi:http://dx.doi.org/10.1162/0011526054622015
Williams, P. J., & Stables, K. (2017). *Critique in Design and Technology Education*. Singapore: Springer.
Wubbels, T. (2011). An international perspective on classroom management: what should prospective teachers learn? *Teaching Education, 22*(2), 113-131. doi:10.1080/10476210.2011.567838