Blended Learning for STEM at Levels 3-6 during the Covid-19 Pandemic and its implications for pedagogy and skills

(A QAA funded research project of experiences at Leeds College of Building and York College)

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1. Executive Summary

This study begins with an introduction (Chapter 2) and detailed literature review (Chapter 3) of existing academic and evidence-based practice relating to blended learning and curriculum development. There is much ambiguity around a unified definition of blended learning and significant debate and theoretical development has taken place over the past 20 years. The most prominent definition of blended learning comes from Graham (2006, p.5) who argued that *"Blended learning systems combine face-to-face instruction with computer-mediated instruction".* However, others (Driscoll, 2002; Garrison and Kanuka, 2004; Boelens et al., 2017; Cronje, 2020) additionally consider the role of pedagogy. The literature review further explores relevant theories and models of blended learning development including: the community of inquiry framework (Garrison and Vaughan, 2008), Graham's (2006) concept of desirable and undesirable blends, Watson's (2008) blended learning continuum, Stoker and Horn's (2012) four models of blended learning, Bidarra and Rusman's (2017) SLAM framework, and finally Ożadowicz's (2020) modified blended learning framework during Covid-19.

A detailed overview of evidence-based research into the use of curriculum models and theories of learning such as Strange and Gibson's (2017) reflective practice framework is also provided. The evidence around the successes and failures of blended learning models presents a mixed picture. According to Nortvig et al. (2018) blended learning could be more effective than either face-to-face or online learning used separately (cf. Adams et al., 2015; Pellas and Kazandis, 2015; González-Gómez et al., 2016). However, other studies found that the opposite was the case, and that achievement was higher amongst face-to-face learners due to increased interaction and reduced isolation (Adams et al., 2015; Powers et al., 2016). This suggests that in order for blended learning to be successful, key barriers need to be identified and overcome (Boelens et al., 2017). Blended learning can also support the competences required for success in a digital and networked world including creativity, critical thinking, problem solving and productivity (Voogt and Pareja Roblin, 2012). However, inequalities exist amongst staff and students in terms of their ability to access and interact with blended learning technologies (European Commission, 2013; Bidarra and Rusman, 2017). Ożadowicz (2020) further argues that Covid-19 has created a need to modernise teaching and learning with new technologies, tools, and organisational approaches. Finally, the literature review explores previous studies of STEM teaching in FE and HE during Covid-19.

Chapter 4 looked at the research aims of this study which were to:

- Review the blended learning experience of students during the Covid-19 lockdown periods; and
- Identify developmental activities that support improved progression from studying, into the workplace, with a focus on digital skills.

These will be achieved by exploring the following research questions:

- What impact did the Covid-19 pandemic during 2020 and 2021 have on students' access to Further/Higher Education at LCB and York College?
- What were the positive aspects (value) of students' blended learning experiences?
- What were the negative aspects (barriers) of students' blended learning experiences?
- How could these barriers be reduced in future in order to enhance access and participation to blended learning?
- How could digital skills and knowledge be enhanced to support better progression into the workplace?
- What developmental activities and materials could be used to support this progression?

Chapter 5 looked at the methodology. Previous studies argued that research on learning environments in general (and blended learning in particular) should employ qualitative methods that explore the perceptions of educators and students through interpretation and description (Gerbic and Stacey, 2009; Saghafi *et al.,* 2010). A multiple case study approach was chosen because of the need to understand a variety of contexts from the perspective of multiple student groups across a range of subjects and academic levels. The sampling and selection of cases within LCB and York Colleges was carried out using a purposive (non-probability) sampling technique. The student groups were selected from a range of level three (full time study programmes and advanced apprenticeships) through to level six (higher and degree apprenticeships) in STEM, construction and built environment subject areas. Data about student and alumni perspectives of blended learning during Covid-19 was generated from LCB and York Colleges using a series of focus groups which were held between June and October 2021. Common questions posed in the focus groups looked at the story of students' learning experience, the LMS and VLEs used, the learning environment, motivation, blended learning beyond lockdown, positive and negative aspects of blended learning, specialist digital and ICT

skills required, units and subjects that did/didn't work well, work experience, and identification of staff/student training needs.

Chapter 6 describes the experiences of students at LCB and York College during the Covid-19 pandemic. The utilisation of LMS and VLE amongst teaching staff was inconsistent (often due to varying degrees of ICT literacy) and many students struggled with the technical aspects of studying STEM online (such as CAD and engineering maths). Students felt that units heavy on theory/legislation were the easiest to learn online, whereas practical sessions such as CAD and surveying were delayed until in-person teaching resumed. Students also struggled with motivation, isolation, and access to a productive workspace, particularly at Level 3. Access to employment also varied significantly during the pandemic with full time Level 3 T-Level and BTEC students reporting significant anxiety around arranging work placements during the pandemic.

Chapter 7 analysed the positive aspects of students' blended learning experiences during the Covid-19 Pandemic. Positive usage of LMS and VLE included more flexible learning and the ability to re-listen/re-watch recorded sessions, which in turn promoted greater reflection. Students were also positive and forgiving of the difficulties of quickly transitioning online. Some students were able to develop the resilience to maintain social connections with peers and even preferred online learning due to convenience and reduced need to travel. However, others felt that it blurred the lines between home, work, and education. In terms of providing individual support to students, evidence of one-to-one support was evident around mental health, maths support, and to facilitate enhanced social interactions. In order to continue the adoption of blended learning across STEM subjects going forwards, developing innovative approaches rather than porting existing ones online will be critical.

Chapter 8 analysed the negative aspects of students' blended learning experiences. There was inconsistent application of LMS and VLE software, delivery, ICT skills and teaching presence. Additionally, the limitations of ICT and digital skills made it challenging for tutors to replicate in-person experiential learning that stimulates all of the senses (Kolb, 1984; Laird, 1985). There also appeared to be a prevalence of behaviourist and theoretical approaches which showed that staff and students were surviving rather than thriving. This reinforces the danger that blended learning tools can be overused without thought for pedagogy. Students appeared to suffer from a weaker sense of identity, lack of structure and co-presence which had a knock-on impact on motivation, social isolation, social networks, and relationships. Home environments

were also not always conducive to blended learning and students reported finding the online delivery of maths for engineering particularly challenging, especially in managing the transition from level 3 to level 4.

Chapter 9 analysed how the barriers to access and participation in blended learning identified by Boelens et al. (2017) could be reduced. Better incorporation of flexibility in BL provisions would require self-discipline from students and trust from staff and employers that those students have the motivation and resilience to take responsibility for their learning (mostly likely at academic levels 5 and 6). This could be promoted and supported by flipped classrooms, complementary training to improve ICT and practical skills, the reinforcing of key concepts from Level 3, and the provision of onsite flexible study spaces beyond the classroom. Better stimulation of interaction in blended learning provisions would require buy-in from staff and students, some of whom spoke negatively about wanting such interaction in this study. This could be overcome by providing space for students to actively participate in sessions so that they don't feel they are disrupting the flow of the lesson; focussing in-person delivery on the more technical and practical aspects of STEM subjects; and ensuring that the relationship between pedagogy, curriculum development and the implementation of online lessons is carefully planned. Better facilitation of student's learning processes would require further development of successful staff-student relationships to promote openness, confidence, and ICT literacy confidence amongst all concerned. Fostering effective learning climates would require on-site alternative study spaces to overcome difficulties around working from home; training and support to build students' resilience, support motivation, and promote wellbeing; and regular opportunities for pastoral, mental health, and learning needs support both in-class and online.

Chapter 10 outlined digital skills and knowledge gaps that students required more support with. These included: ICT literacy; independent learning and critical thinking skills; self-motivation and resilience; self-directed software tutorials to complement learning in class for Revit and CAD; fundamentals of engineering mathematics; and creating and maintaining professional networks. In order to address this, **two interventions are recommended: the development of a linear CPD programme of 20 sessions for tutors to enhance their use of blended learning; and a nonaccredited course on digital skills and employability for FE and HE students at levels 3-6 made up of 16 modules/tutorials that could be delivered in-person or online**. The success of these pilot interventions can be evaluated using Strange and

Gibson's (2017) reflective practice framework, which would involve continuous feedback from both staff and students in the sector.

Finally, Chapter 11 provides an overview of the key findings from the analysis chapters (6-10) and Chapter 12 provides a more detailed outline of the development of new blended learning activities and materials relating to the indicative content for the 20 session CPD programme for FE/HE staff working in STEM subjects and the 16 nonaccredited tutorial modules for students studying STEM subjects at Units 3-6.

2. **Introduction**

The Covid-19 Pandemic has had a seismic impact on many aspects of daily life across the world. One area where this impact has been as strong as any is in the delivery of and access to education. This study has been commissioned by the Quality Assurance Agency for Higher Education (QAA) in order to review the student experience of blended learning during the lockdown period(s).

Leeds College of Building and York College have been jointly involved in the delivery of a research project which focused on the impact of the Covid-19 Pandemic from the specific perspective of STEM subjects (across Levels 3 to 6) as the nature of these courses do not lend themselves easily to blended learning due to significant practical elements. These Colleges were selected because they have adopted a variety of approaches to blended learning and have a wide range of students from diverse backgrounds (with variable access to ICT devices and Wi-Fi) and with various levels of practical and academic experience. In order to complete this research a broad range of students and alumni were invited to take part in a series of focus groups which reflected both the experience of those in Level 3 full-time study programmes looking for work experience to those on Higher and Degree Apprenticeships who are in full time training with an employer.

This study will explore the findings of the focus groups in terms of the impact of students' experiences of access to FE and HE through blended and online learning during the Covid-19 Pandemic. This will be followed by an analysis of the positive and negative aspects of those experiences and how those impacts can be mapped against Graham's (2006) desirable blends and the key challenges or barriers to the design of blended learning environments (Boelens et al., 2017). Measures to address those barriers will then be proposed and two interventions to enhance digital skills and knowledge amongst FE and HE staff, and students will be proposed.

These will take the form of non-accredited modules that can be taken as part of the ongoing CPD programme at partner institutions for staff and as part of tutorial sessions for students.

3. **Literature Review: Blended Learning and Curriculum Development**

This literature review will explore academic and evidence-based practice into blended learning and curriculum development. This will also include a consideration of the barriers to a blended model, the role of digital skills in progression to the workplace, and a review of further and higher education during Covid-19. This in-turn will inform the research questions and methodology used in the delivery of this project.

3.1. **Definitions of Blended Learning**

There is much ambiguity in both the academic literature and across the education sector as a whole around a unified definition of blended learning. As a result, it has become an umbrella term for the use of technology in education (Hrastinski, 2019). Some authors have been critical of this ambiguity with Oliver and Trigwell (2005) stating that blended learning semantically represents two or more things that can be mixed. The term itself seems to have been coined in the late 1990s by a 1999 press release by EPIC Learning (Cronje, 2020; Friesen, 2012). Significant debate and theoretical development on the subject of blended learning then took place during the early 2000s (Hrastinski, 2019). Floridi (2014) further argued that the world has become an 'infosphere' which is reshaping human reality and therefore blended learning can almost be considered to be the 'new normal' from an educational perspective (Dziuban et al., 2018).

The most prominent definition of blended learning (according to evidence provided by Hrastinski (2019) and Cronje (2020)) comes from Graham (2006, p.5) who argued that *"Blended learning systems combine face-to-face instruction with computer-mediated instruction"*. Driscoll (2002) on the other hand regarded blended learning as being a combination of different online technologies, pedagogical approaches, instructional technologies, and active tasks. Garrison and Kanuka (2004, p.96) developed this idea further by stating that blended learning is *"the thoughtful integration of classroom face-to-face learning experiences with online learning experiences"*. This definition therefore considers the quality of the provision as well as the use of technology and different approaches.

More recent research has continued to refine and challenge these early definitions. For example, Nortvig *et al.* (2018) argued that agreement has still not been reached on a commonly

accepted definition of blended learning. Ryan *et al.* (2016) suggested that the terms blended learning and hybrid learning are being used interchangeably in contemporary education. Boelens *et al.* (2017) argued that blended learning required the development of innovative approaches rather than simply porting existing ones into the online sphere. Additionally, they felt that blended learning shouldn't just be seen as the use of learning management systems (LMS) or virtual learning environments (VLE) such as Moodle and Blackboard. Hrastinski (2019) proposed that blended learning was made up of subsets or 'conceptualisations' such as: inclusivity, quality, synchronicity, digital technologies, instructional methods, and active learning. Finally, Cronje (2020) provided a more nuanced definition of blended learning which was inclusive of context, theory, methodology and technology. This was presented within Cronje's (2020) Blended Learning Decision Matrix and will be covered in more detail in the following section.

3.2. **Theories of Blended Learning Development**

There has been significant coverage in the pedagogical literature on how blended learning models and curricula are developed (*cf.* Hrastinski, 2019) and this section will summarise some of these theories and models which are highly variable in terms of their descriptive and theoretical development. The order in which these are presented here does not reflect any particular indicator of quality or relevance, but the theories and models are presented chronologically with the exception of a STEM specific and Covid-19 specific model which are outlined at the end of this section.

The community of inquiry framework for online learning (cf. Garrison *et al.,* 2000; Garrison and Vaughan, 2008) was not developed specifically for blended learning but online learning, however, it is one of the most influential models used (Hrastinski, 2019). A community of inquiry combines open discourse and reflection across three types of presence: teaching, cognitive, and social (Figure 2.1). Teaching presence relates to the amount of interaction provided by the teacher including clear and relevant goals and direction. Cognitive presence relates to a student's engagement with learning and the goals/direction provided by the teaching presence. Finally, social presence relates to the level of engagement that students have with each other. Hrastinski (2019, p.565) argued that "Blended learning should thoughtfully integrate classroom face-to-face learning experiences with online learning experiences to enable communities of inquiry".

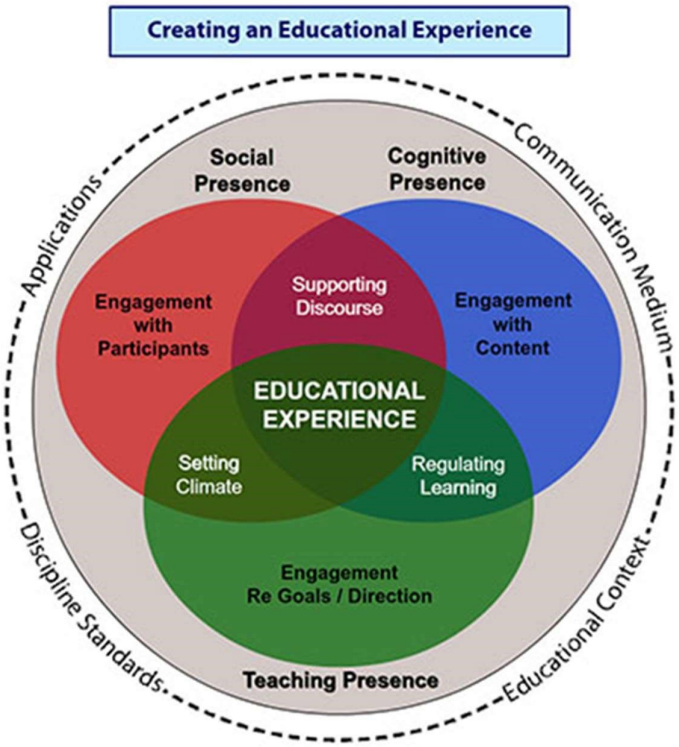


Figure 2.1: Garrison et al.'s (2000) Community of Inquiry Framework (After University of Wisconsin-Madison, 2016)

Graham (2006) introduced the concept of desirable and undesirable blends which relates to the strengths and weaknesses of face-to-face versus online learning (Table 2.1). In other words, the advantages should be maximised, and the disadvantages should be minimised (Hrastinski, 2019). Hrastinski (2019) therefore suggests that the model of desirable blends could be used to analyse the strengths and weaknesses of different blended learning activities. Graham (2006) also proposed a typology of the different levels of blend which relates to the scale of institutional change and the categories of blend which relates to the depth of change from traditional teaching and learning methods. The levels of education where blended learning can be introduced range from activity-level through to course-level, program-level and institutional-level. Whereas the categories of blend involved (Graham, 2006):

- Enabling blends – Improving access and convenience through LMS
- Enhancing blends – Evolution of pedagogy rather than radical change
- Transforming blends – Dynamic and radical change of pedagogy

Table 2.1: Strengths and Weaknesses of face-to-face and online learning environments (Graham, 2006, p.18)

	Online	**Face-to-face**
Strengths	**Flexibility** (convenience of time and place) **Participation** (time and place constraints removed) **Depth of Reflection** (learners have time to develop more thoughtful reflections)	**Human Connection** (easier to bond and develop trust) **Spontaneity** (generation of rapid ideas and discoveries)
Weaknesses	**Spontaneity** (doesn't encourage rapid ideas and discoveries) **Procrastination** (more self-discipline is required) **Human Connection** (an impersonal approach that may lead to lower satisfaction)	**Participation** (can be dominated by more confident personalities) **Flexibility** (limited time may restrict the depth of discussions)

Watson (2008) regarded blended learning as being where online and face-to-face education converges and presented a model of blended learning as being a continuum between fully online and fully face-to-face learning. This continuum was then subdivided into seven-points (Figure 2.2) which describe different amounts and flexibility of online provision. Hrastinski (2019) points out that this only provides a descriptive technological distinction rather than a theoretical one (i.e., the how of blended learning rather than the why).

Figure 2.2: Watson's (2008) blended learning continuum

Staker and Horn (2012) provided a detailed categorisation of blended learning (Figure 2.3) which they argued represented the most common types of blended learning programmes in US K-12 education (covering ages five through to 18). Four models of blended learning were identified: the rotation model, the flex model, the self-blend model, and the enriched-virtual

model. The **rotation model** involves a programme which switches between modes of delivery at the discretion of the teacher such as: full class instruction, group projects, individual tutoring, and online learning (Staker and Horn, 2012). This model is then sub-divided into types of rotation that are mostly part of a fixed schedule that all students carry out together or in small groups (station rotation, lab-rotation, and flipped-classroom) as well as individual-rotation which puts students onto their own customised bespoke programme.

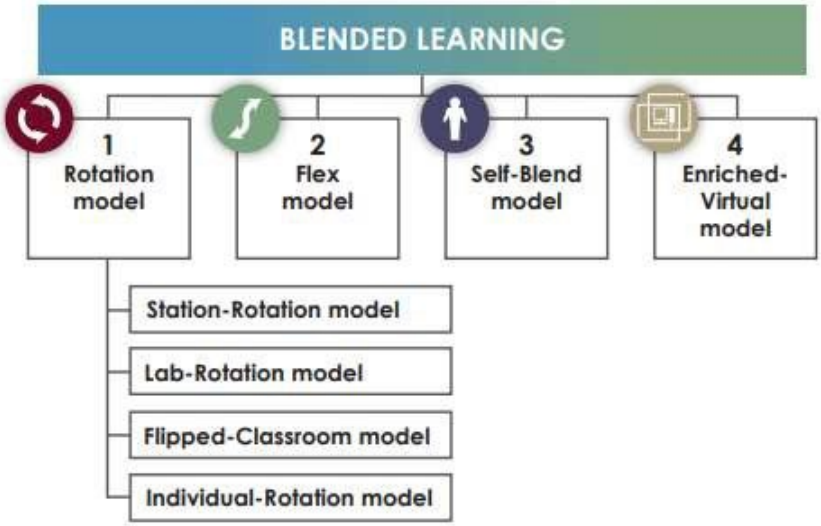


Figure 2.3: Staker and Horn's (2012) four models of blended learning

Turning attention to the other three models (Staker and Horn, 2012), the **flex model** involves mostly online learning that is individually customised with face-to-face support provided on a flexible basis. In a **self-blend model**, online courses are used to supplement traditional courses. These tend to be optional and can be facilitated onsite or off site. Finally, the **enriched-virtual model** divides students' time between online and in-person delivery. Whilst there are similarities between these models, they are differentiated by whether or not they apply to an entire institution or just specific courses, as well as whether students need to attend in-person regularly or not. This division of online and in-person learning was sometimes reflected by the approaches taken in York College and Leeds College of Building (particularly in the Higher Education, Construction, Design and Management Department (HECDM)) during the second and third waves of the Covid-19 Pandemic in the UK.

Saghafi et al. (2014) looked at the role of blended learning in HE architectural and design education and considered the relationship between the location and method of delivery. As part

of this study, they provided a detailed breakdown of the attributes and characteristics of different place-time models and set out four place-time dimensions of blended learning:

- SP-ST (same place and time) – such as formal face-to-face learning in a classroom environment, practical workshops, and site-visits/fieldwork
- SP-DT (same place but different time) – informal spaces for casual interaction
- DP-DT (different place and time) – asynchronous virtual learning environments (such as Moodle and Blackboard)
- DP-ST (different place but same time) – live online environments (such as Microsoft Teams and Zoom)

Saghafi *et al.* (2014) argued that a holistic model for blended learning was required which could utilise the benefits of both face-to-face and online environments. For example, they found that face-to-face learning was better for developing social interactions, relationships, collaboration, and engagement. However, online learning made it easier to share digital files and work. Saghafi *et al.* (2014) felt that blended learning was preferable to choosing face-to-face over online or vice versa because the limitations of one environment can be counteracted by the other. They also argued that enabling self-determination, self-management and personalisation were key aspects of blended learning.

In terms of the development of general educational models of blended learning, Cronje (2020) provided a detailed critique which suggested that previous models were devoid of theory and that they should be built around pedagogy. This built on a body of work by Cronje and others (cf. Elander and Cronje, 2016; and Elen, 2017) which looked at the relationship between pedagogy and blended learning. Cronje's (2006) earlier theoretical work suggested that seeing behaviourism and constructivism (see also Section 2.3 below) as opposing theories was a false dichotomy. Instead, these learning paradigms should be seen as interactions along a matrix (Figure 2.4) which divides blended learning into four quadrants (Cronje, 2006; 2020):

- Construction (High Constructivism-Low Objectivism)
- Injection (High Objectivism-Low Constructivism)
- Integration (Presence of both learning styles are high)
- Immersion (Low evidence of either learning style represents informal learning)

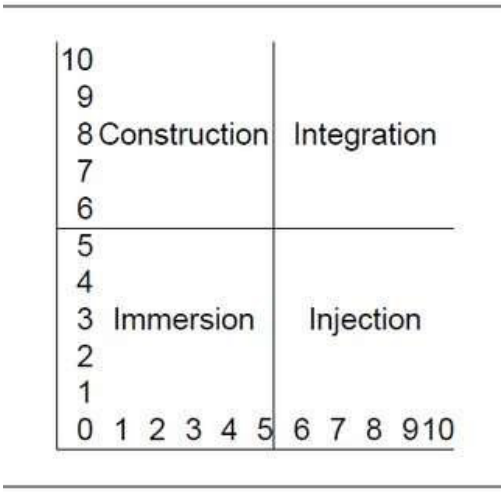


Figure 2.4: Cronje's (2006, p.392) integration of the objectivist and constructivist learning paradigms

Cronje (2020) argued that the selection of face-to-face or distance learning was a subset of contexts and that Kurtz and Snowden's (2003, p.464) Cynefin Framework could be used to establish these contexts. The Cynefin Framework divides context into four domains (Cronje, 2020): the complex domain, the knowable domain (puzzles rather than problems), the chaos domain (real life experience or being thrown in at the deep end, the domain of the field trip or apprenticeship), and finally the known domain. Cronje's (2020) study combined the cynefin framework (context) with their 2006 matrix (theory) to argue that blended learning was inclusive of context, theory, methods, and technology. The resulting model (Table 2.2) which can be used as a guide on how and when to blend was termed the **Blended Learning Decision Matrix** (Cronje, 2020).

Table 2.2: The Blended Learning Decision Matrix (Cronje, 2020, p.120)

Context (Kurtz & Snowden)	Theory (Cronje)	Methods	Technologies
Known	Injection	Tutorial Drill	Lecture Book Video
Complex	Construction	Construction Exploration	Open-ended learning environments Construction kits and tools Spreadsheets
Knowable	Integration	Puzzle Discussion Debate	Games Discussion tools
Chaos	Immersion	Experience Field trip Apprenticeship	Blogs Logbooks Assessment tools

Within Science, Technology, Engineering and Maths (STEM) education specifically, Bidarra and Rusman (2017) also attempted to develop a framework for blended learning that was sensitive to context, pedagogy, and technology. Although it can be argued that the focus here was much more on how online technologies are implemented. The Science Learning Activities Model (SLAM) was designed as a framework (Figure 2.5) to better link STEM to real-world situations and improve the attractiveness of the subject to prospective students because *"UK youngsters indicated that they would be more engaged with science if it were more applicable and relevant to contemporary life and transferable to 'real-world' situations"* (Bidarra and Rusman, 2017, p.7). Bidarra and Rusman (2017, p.11) argued that the SLAM Framework could benefit from interrelationships between digital storytelling and gamification and that this could make learning more *"experiential, memorable and intense"*. The model also complements the recent report on *Innovating Pedagogy* published by the Open University (2015).

	Seamless dualities	Typical features
Context	1. Formal and non-formal learning	Specification of topics and types of science activities and how they fit together in a learning scenario (e.g. lab, science centre, field trip, etc.)
	2. Individual and collaborative learning	Specification of science study modes and related resources (allowing for learners' PLEs and social networks).
	3. Open and closed learning environment	Combination of free and restricted access learning environments and resources (e.g. MOOC and SPOC)
Technology	4. Synchronous and asynchronous learning	Technology supporting science learning interaction modes (time dimension in Johansen's matrix)
	5. Virtual and physical interaction	Technology for blended learning interaction (deals with the space dimension in Johansen's matrix)
	6. Single platform and multi platform	Online learning platform integration as needed (e.g. Moodle, Moodle Mobile, Elgg, Blackboard, Edmodo)
Pedagogy	7. Theoretical and hands-on activities	Mix of learner-centred science activities set in a blended learning curriculum (including activities based on PLEs and social networks).
	8. Restricted and open learning design	Design of structured activities for restricted outcomes (e.g. multiple-choice tests and tutor marked assignments), and design of open activities (e.g. games, simulations, portfolios and open discussions)
	9. Centralised and open assessment	Modes of learner assessment components in a learning scenario with many activities (e.g. formative and summative assessment, peer assessment, self-assessment)
	10. Pre-structured and open guidance	Modes of scaffolding the learning process and tutoring of activities (e.g. tutorials and peer-guidance)

Figure 2.5: The SLAM Framework (Bidarra and Rusman, 2017)

Finally, Ożadowicz (2020) presented a modified blended learning framework which was required during Covid-19 lockdowns (Figure 2.6). However, it can be argued that this focuses too heavily on the swift transition to remote technologies at the expense of pedagogy which is reflective of how many FE, and HE courses handled the immediate and sudden transition in March 2020.

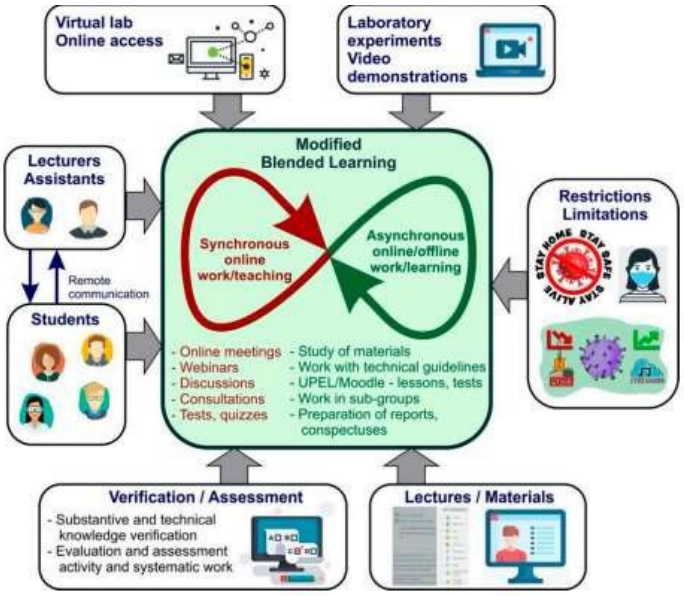


Figure 2.6: Modified Blended Learning Framework during Covid-19 (Ożadowicz, 2020)

This study will further consider the relevance of these models within the analysis of the research findings (Chapters 9 and 10) and the recommendations made in support of the development of new activities (Chapters 11 and 12) to support blended learning in Further and Higher Education for STEM subjects.

3.3. **Curriculum Models**

This section will consider existing evidence-based research into the use of curriculum models in education, this includes a brief summary of commonly adopted theories of learning, followed by a discussion of curriculum model theories, and finally an overview of the practices to curriculum development adopted by Leeds College of Building.

3.3.1. **Theories of Learning**

Cronje (2020) argued that existing definitions of blended learning were devoid of theory (instead focussing on the use of technology) and that it should be built around learning theory. This study will therefore consider the relationship between blended learning and learning theory. The pedagogical literature considers a variety of different theories on the topic of how people learn (Gravells and Simpson, 2014) which in turn influence the development of new curricula in FE and HE. Commonly utilised learning theories include but are not limited to behaviourism, cognitivism, constructivism (Vygotsky, 1978), experiential learning (Kolb, 1984), humanism, pragmatism, Bloom's (1956) taxonomy, and sensory theory (Laird, 1985). The following paragraphs will define these in more detail.

Behaviourism is a traditional and passive form of learning which relies on positive and negative reinforcement that can be useful in certain contexts. Cognitivism focuses on thinking and problem solving and the mental processes required to acquire new knowledge (Gravells and Simpson, 2014). As a theory it highlights the need for active rather than passive participation in order for students to gain both knowledge and understanding. Constructivism (Vygotsky, 1978) argues that everyone constructs their own unique interpretations of knowledge and the world around them based on sociocultural interactions. Kolb's (1984) experiential learning cycle (Figure 3.1) builds on constructivist theory by considering the value of immersive experience, observation, and reflection in making sense of concepts and experiences and what we can learn from them. This enables students to understand concepts through their experiences and is an important reason why practical activities are used so extensively in teaching. Saghafi *et al.* (2014) argued that blended learning should be closely aligned to constructivist theory given that both are effective at enabling group problem-solving and collaboration (*cf.* Bonk *et al.*, 2006; Cross, 2006; Eilouti, 2007; Fisher, 2004; Jochems *et al.*, 2004).

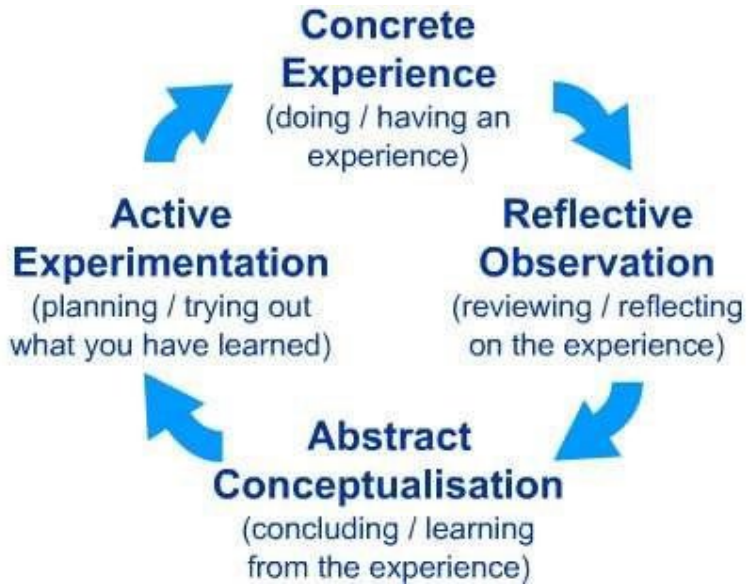


Figure 3.1: Kolb's learning cycle (University of Puget Sound, 2020)

Humanism connects learning with the person as a whole and considers learning to be a journey of personal growth. In humanism the teacher is a facilitator that creates an environment where students feel safe to discuss new ideas and to make mistakes (Gravells and Simpson, 2014). Pragmatism theory argues that learning requires a variety of activities rather than teacher-focussed instruction. Teachers that plan a variety of activities in their lessons are likely to promote active engagement and also accommodate different learning styles. Bloom *et al.* (1956) focused on the need to use higher forms of thinking when designing teaching, learning and assessment strategies rather than simply transferring facts. This involved classifying learning into three parts (or domains): knowledge, skills, and attitudes (or think-feel-do) and Bloom's taxonomy (Figure 3.2) suggests that each of these domains can be taught and learned at increasing levels of difficulty (from remembering to creating) which students must go through in order to master a subject (Gravells and Simpson, 2014; Anderson and Krathwohl, 2001).

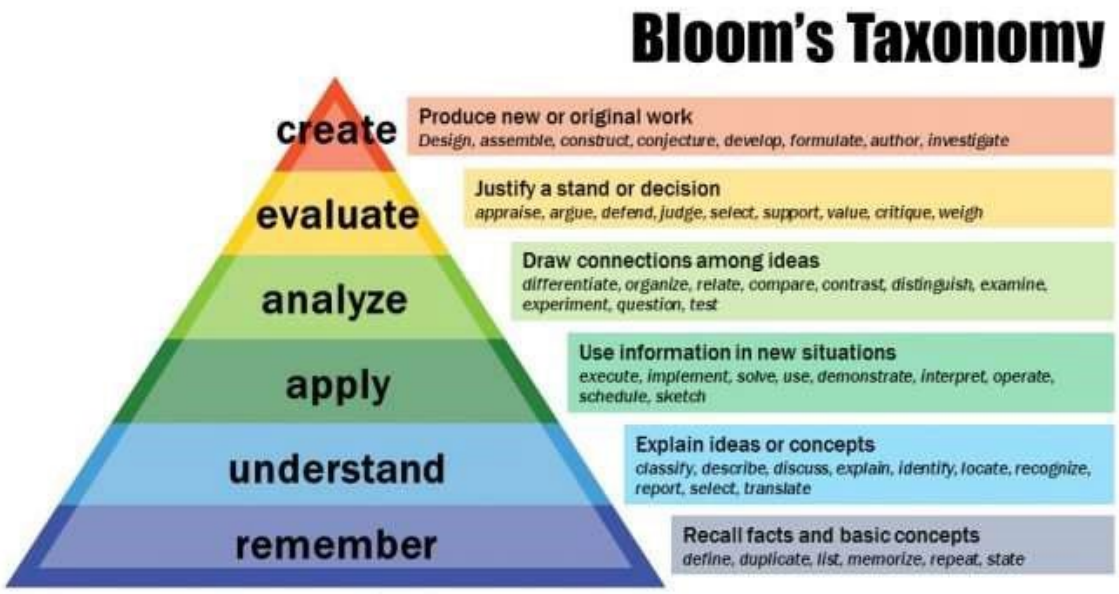


Figure 3.2: Bloom's Taxonomy (Vanderbilt University Center for Teaching, 2020)

Finally, sensory theory (Laird, 1985) expands on Kolb's (1984) cycle of experiential learning by suggesting that learning occurs when all of the senses are stimulated. As Gravells and Simpson (2014, p.93) point out: *"this is easy if you are teaching a practical session, but not so if you are teaching a theoretical subject."* However, it can be a rewarding and memorable approach from the perspective of the student experience.

3.3.2. **Curriculum Model Theories**

Alongside the learning theories outlined above, there has also been extensive coverage of curriculum models in pedagogical literature. Curriculum is about the substance of teaching in terms of what learners will need to know and get out of the experience. Ofsted (2019) define curriculum as being something that passes through three stages: **intent** (the framework of an education programme as conceived), **implementation** (translating the framework into a structure and narrative through teaching, learning and assessment), and **impact** (evaluation of what learners have gained in terms of knowledge and skills). This section will now consider some of the most commonly recognised curriculum models which includes: the product model, process model, praxis model, thematic model, and spiral model.

Smith (2000) suggested that there were clear links between the first three models because they can all be matched to Aristotle's categorisation of knowledge into the theoretical, the practical and the productive (Figure 3.3).

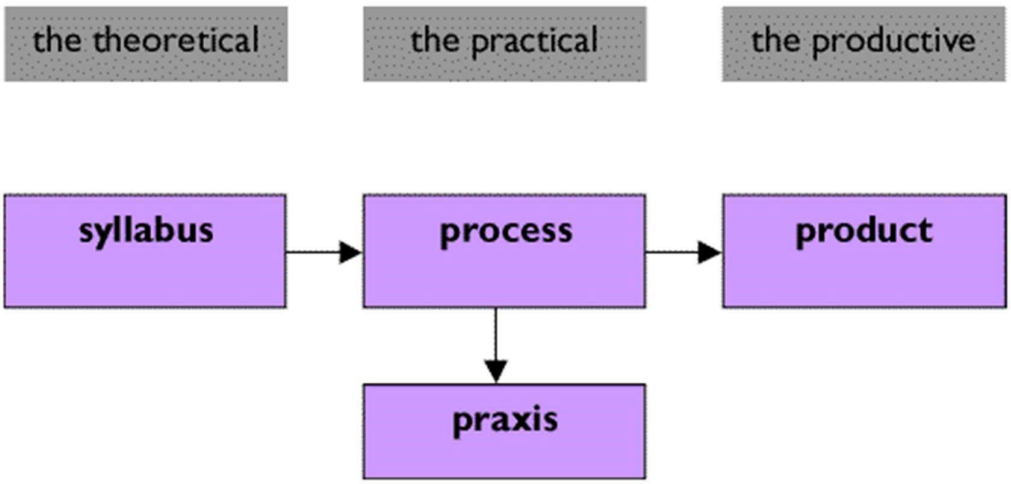


Figure 3.3: Links between common curriculum theories (Smith, 2000)

The **product model** for curriculum development focuses on the end result, which is analogous to the destination being more important than the journey (Barron, 2020). This links measures of success from a learning point of view to achievement and is a commonly adopted approach in education. The product model tends to lead to a curriculum that has a clear and logical structure where learners are aware of the goals and what they need to do to achieve them (Barron, 2020). In terms of linking this model to learning theory, Behaviourism and Bloom's (1956) taxonomy fit well with an assessment driven curriculum.

The next approach is the opposite of the product model. Stenhouse (1975) proposed a **process model** for curriculum development where creating was more important than the result. Barron (2020) suggests that this is analogous to the journey being more important than the destination. This model encourages people to think creatively with less emphasis on the end result, so lends itself well to skills-based activities where the main goal is to practice something. In linking the process model to learning theory, it best fits constructivism (Vygotsky, 1978) and Kolb's (1984) learning cycle with its focus on interaction and experience. Barron (2020) urges caution however because learners who don't appreciate the value in the process might see this approach as an unproductive waste of time.

The **praxis model** takes the process model a stage further by considering how curriculum development directly serves human wellbeing and the emancipation of the human spirit (Grundy, 1987; Smith, 2000). This ties the process of learning to critical pedagogy where students and teachers are encouraged to think critically and work through real-world problems

together (Grundy, 1987; Yek and Penny, 2006). Praxis can be defined as informed, committed action (Smith, 2000) which means that: *"the curriculum is not simply a set of plans to be implemented, but rather is constituted through an active process in which planning, acting, and evaluating are all reciprocally related and integrated into the process"* (Grundy, 1987, p.115). In practice, this would mean that the curriculum is responsive and receptive to real-life events as a means of contextualising STEM in the real world.

The final two models focus more on the coverage of topics rather than the actions of the students and teachers. The **thematic model** focuses on the grouping of topics into themes of interest. This can have the advantage of being engaging if the topic is a popular one but conversely if a student isn't interested in a topic, they can find the lessons boring or irrelevant (Barron, 2020). This might involve focussing the curriculum on a specific case study which can be useful but is also heavily influenced by the interests and biases of the teacher. The **spiral model** involves revisiting the same topic multiple times at varying levels of depth depending upon the academic level of study (Gould and Roffey-Barentsen, 2014; Barron, 2020). For example, a transport planning apprentice in the initial stages of their career might complete a Level 3 Advanced Technician Apprenticeship, a level 6 Degree Apprenticeship, and then a Level 7 Master's Degree (or a selection of the above). In each case the same topics are covered but at increasing levels of complexity and critical evaluation. This can also be used within a curriculum as part of the process of scaffolding and checking students' existing levels of knowledge and skills.

Many curricula are developed using multiple models outlined above because teachers and institutions are increasingly recognising the value of both the means and the ends (process and product). In order to take this a step further by focussing specifically on blended learning, Strange and Gibson's (2017) **reflective practice framework** (as adapted by ElSayary, 2021) illustrated the way in which the combination of transformative and experiential learning can promote concrete learning. This means that it adopts the experiential approach of a process model, the outputs of a product model, and the reflexiveness of the praxis model. The framework (Figure 3.4) requires staff and students to critically reflect upon their assumptions, knowledge, and experiences throughout the learning journey. However, ElSayary (2021) argues that there is disagreement in the literature about who is able to utilise transformative learning. On the one hand some authors argue that transformative learning only applies to adults because children are less able to experience and critically reflect on their learning that leads to transformation (Merriam, 2004; Taylor, 2007). Whereas other research found that

transformative learning was more effective when it is started at an early age (NRC, 2000; Singleton, 2015). Given the FE and HE focus of this study, the reflective practice framework is highly relevant in understanding the role and impact of blended learning of STEM subjects during and after the Covid-19 Pandemic.

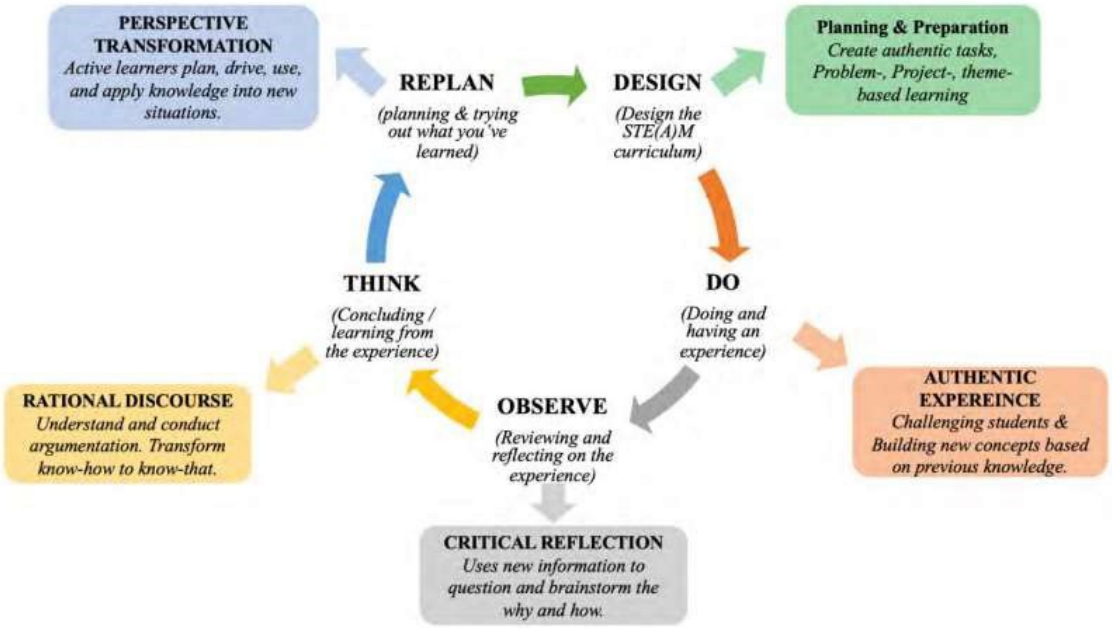


Figure 3.4: Strange and Gibson's (2017) reflective practice framework (ElSayary, 2021)

3.3.3. Curriculum Models adopted by the Colleges in this study

Leeds College of Building's most recent Teaching, Learning and Assessment Strategy included the implementation of the CSPARr learning cycle model (TLC, 2014; LCB, 2019) in 2019-20. The model (Figure 3.5) was adopted because *"The learning cycle provides us with a cohesive and clear structure to a lesson and the learning process. The separate stages of this cyclical model enable the use of a common vocabulary, which sets out clear expectations for our professional practice. The model focusses on an evidence-based approach to learning in order to develop and build upon prior learning and experiences."* (LCB, 2019, p.3). The five components of the learning cycle model stand for (LCB, 2019):

- Connect (connecting to previous learning and engaging at the outset)
- Share (sharing the structure of a lesson in a meaningful way)
- Present (learners engage with new knowledge, skills, or concepts)
- Apply (learners demonstrate their understanding)
- Recall and Review (embeds and checks the extent of new learning that took place)

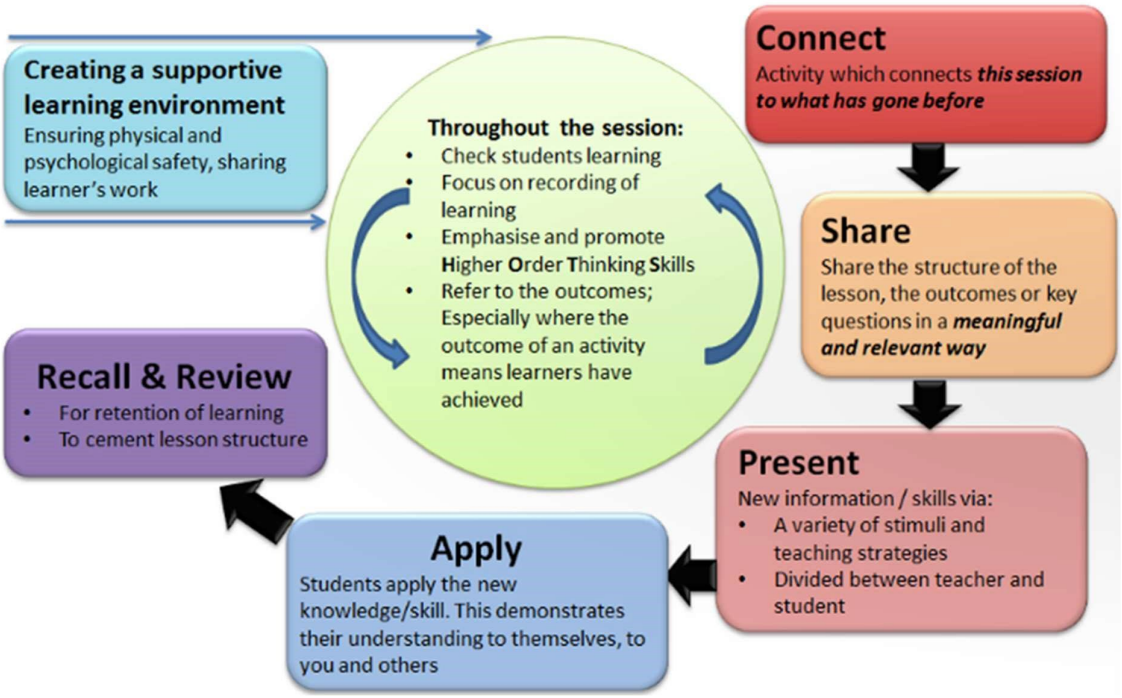


Figure 3.5: The CSPARr Model (TLC, 2014 and LCB, 2019)

3.4. Barriers to a blended model

The evidence around the successes and failures of blended learning models presents a mixed picture. According to Nortvig *et al*. (2018) a review of relevant literature suggested that blended learning could be more effective than either face-to-face or online learning used separately (*cf.* Adams *et al.*, 2015; Pellas and Kazandis, 2015; González-Gómez *et al.*, 2016). This review also argued that achievement rates are slightly better in higher education settings on blended programmes when compared against traditional classroom approaches (Bernard *et al.*, 2014; Isreal, 2015; Northey *et al.*, 2015; Southard *et al.*, 2015; Gonzalez-Gomez *et al.*, 2016; and Ryan *et al.*, 2016). However, other studies found that the opposite was the case, and that achievement was higher amongst face-to-face learners due to increased interaction and reduced isolation (Adams *et al.*, 2015; Powers *et al.*, 2016). This suggests that in order for blended learning to be successful, key barriers need to be identified and overcome. For example, the European Commission (2013) found that 50-80% of students *"never use digital textbooks, exercise software, podcasts, simulations or learning games"*, whilst 70% of teachers would like more ICT training (Bidarra and Rusman, 2017, p.9).

Boelens *et al.* (2017) carried out a detailed and systematic literature review which addressed four key challenges (barriers) to the design of blended learning environments: **incorporating flexibility, stimulating interaction, facilitating students' learning processes, and fostering an effective learning climate**. These are defined below and are further considered by the empirical research carried out during this study (Chapters 6-8).

Incorporating flexibility enables learners to have some control over the time, place, path, or pace of blended learning (Horn and Staker, 2014). This agency and sense of being in control is important in building students' own sense of learner identity (Baxter and Haycock, 2014) which will in part be influenced by students' prior experience with social media (i.e., some will be confident whilst others will be hesitant) (Nortvig *et al.*, 2018).

Stimulating interaction involves tackling the difficulties around social interactions (both in terms of staff-student and intra-student interactions) caused by the increasing transactional distance (Moore, 1993) of education in a blended learning environment. Research by Tomas *et al.* (2015) and Joksimovic *et al.* (2015) further support the need to address this key challenge as they highlighted the importance of meaningful blended learning communities which include: peer interactions and collaboration, engaging academic content, a strong teaching presence, and learning achievement (Nortvig *et al.*, 2018).

Facilitating students' learning processes involves ensuring that students have the self-regulation skills necessary for successful participation in blended learning (McDonald, 2014). However, this is more likely to benefit high achievers and additional training might be required for less able learners (Boelens *et al.*, 2017; Owston *et al.*, 2013; and Tsai and Shen, 2009). This would include tackling variations in technological proficiency between different learners (Saghafi *et al.*, 2014). Vermunt and Verloop (1999) provided a framework for the improvement of self-regulation skills (orienting and planning, monitoring, adjusting, and evaluating) which could be mapped to existing models of curriculum development (such as the CSPARr model used at Leeds College of Building).

Finally, **fostering an effective learning climate** involves tackling the significant barriers and challenges to online learning including feelings of isolation and reduced motivation. Therefore, it is important that learners feel safe, accepted, and valued. This includes helping learners to develop the resilience to deal with their emotions (Boelens *et al.*, 2017; Vermunt and Verloop, 1999). Nortvig *et al.* (2018) argued that the availability of appropriate teaching and learning spaces, engaging and meaningful learning communities that support social interactions and

relationships, and a keen sense of learner identity were an important part of blended learning. In particular, they highlighted the work of Saghafi *et al.* (2014) who argued that online learning reduces interaction between students and teachers and that both online and face-to-face settings have their uses but must complement rather than replace one another. Saghafi *et al.* (2014) also found that HE students felt that workshops (either real or virtual) provided a critical learning space for skills training, discussion, peer learning and a review of both individual and learner progress (Nortvig *et al.*, 2018).

3.5. Digital Skills and Progression to the Workplace

Active learning (such as inquiry-based learning, problem-based learning, and collaborative learning) can support the competences required for success in a digital and networked world including creativity, critical thinking, problem solving and productivity (Voogt and Pareja Roblin, 2012). Digital skills and ICT are a critical component of this, in part because online interaction has become a way of life for contemporary students whose expectations and perceptions differ from previous generations (Black, 2010; Tapscott, 2008). In the classroom this has meant that an almost bewildering range of educational technologies are now available including smartphones, networking software, virtual learning environments, applications, and open educational resources (Bidarra and Rusman, 2017). Blended learning in particular provides significant opportunities to best utilise these technologies through innovation and experimentation (including augmented reality, online sharing of resources and virtual communication).

Inequalities exist amongst staff and students in terms of their ability to access and interact with blended learning technologies (European Commission, 2013; Bidarra and Rusman, 2017). Amongst students this can have a knock-on impact on their employability and readiness for the demands of STEM and construction-related industries. Ożadowicz (2020) argues that Covid-19 has created a need to modernise teaching and learning with new technologies, tools, and organisational approaches. In turn, this additional exposure to technologies may be useful for students beyond their course, in terms of the digital skills required in the workplace.

3.6. Previous studies of STEM teaching in FE and HE during Covid-19

Whilst the impacts of Covid-19 on STEM education as of 2022 can only be understood in the context of the immediate aftermath rather than the medium-long term, a variety of studies have already been published in the academic literature looking at different contexts in a variety of

countries and educational systems. This section provides a brief summary of their findings in the context of their relevance to this study.

Ożadowicz (2020) carried out a study which looked at the use of blended learning to teach Engineering in Higher Education during the first Covid-19 lockdown. Ożadowicz (2020) found that there was an increased effectiveness in students' ability to search and acquire knowledge. This included the use of mobile devices which provided a more dynamic or active focus. The predominant activities undertaken during distance learning involved the use of lectures, videos, quizzes, and lab demonstrations; however, it was argued that in person laboratory classes were an irreplaceable element due to the specialist hardware and software required to study engineering in HE (Ożadowicz, 2020).

ElSayary (2021) carried out qualitative interviews of teaching staff at 18 private middle schools in the United Arab Emirates which reflected upon their perceptions of teaching STEM during the Covid-19 pandemic. This study argued that the learning and skills needed in the future will be different from pre Covid-19 and identified that the sudden transition into lockdown enabled transformative change to occur in the IT skills of staff and students. However, this transformation had also presented some challenges. For example: some students found it difficult to stay on task online, the pace of learning was slower, students and teachers with higher IT skills were more engaged and efficient, and more training was required in order to efficiently use LMS and VLE (ElSayary, 2021).

Krishnapatria (2020) carried out an online questionnaire which looked at student perceptions of e-learning during the Covid-19 pandemic in Indonesia. They looked specifically at students of International Business of Padjadjaran University taking English for Business Purposes and Speaking for Business Purposes courses. Krishnapatria (2020) found that whilst 100% of students participated in e-learning during the pandemic, this was not without difficulty. 3.6% of students had to borrow electronic devices from their friends whilst 14.3% reported having a poor internet connection. These limitations were not limited to technology with 41.1% reporting that they struggled to understand the e-learning material and that as a result of these combined technological and learning challenges, only 56% of respondents were satisfied with online e-learning provision. Krishnapatria (2020) felt that this disparity was explained by the different learning styles and technological literacy of students.

Finally, Lockee (2021) published a response paper which specifically considered the rapid shift to digital teaching and learning and the knock-on impact that has had on teacher professional

development (TPD). They argued that TPD for blended learning needed to reflect the different learning and performance contexts caused by the Covid-19 pandemic, particularly in terms of the impact of shifting to online learning on teacher emotion, motivation, and levels of anxiety (and by extension mental wellbeing). Lockee (2021) further suggested that teachers "had to operate within the lower levels of Maslow's hierarchy [of needs], striving simply to survive and carry out their responsibilities as best they can". It is with this in mind that this study seeks to explore the opportunities for training and professional development (for both staff and students) that provide support and give confidence to try new things which moves away from a punitive deficit model for enhancing teaching and learning.

4. Research Aims and Objectives

The research aims of this study are to:

- Review the blended learning experience of students during the Covid-19 lockdown periods; and
- Identify developmental activities that support improved progression from studying, into the workplace, with a focus on digital skills.

These will be achieved by exploring the following research questions:

- What impact did the Covid-19 pandemic during 2020 and 2021 have on students' access to Further/Higher Education at LCB and York College?
- What were the positive aspects (value) of students' blended learning experiences?
- What were the negative aspects (barriers) of students' blended learning experiences?
- How could these barriers be reduced in future in order to enhance access and participation to blended learning?
- How could digital skills and knowledge be enhanced to support better progression into the workplace?
- What developmental activities and materials could be used to support this progression?

5. Methodology

Previous studies have argued that research on learning environments in general (and blended learning in particular) should employ qualitative methods that explore the perceptions of educators and students through interpretation and description (Gerbic and Stacey, 2009; Saghafi *et al.*, 2010). In order to provide a nuanced understanding of the perceptions and experiences of students utilising blended learning during the Covid-19 pandemic, a qualitative methodology was therefore deemed appropriate for this study.

A case study approach was chosen because of the need to understand a variety of contexts from the perspective of multiple student groups across a range of subjects and academic levels. Case studies "focus on one (or just a few) instances of a particular phenomenon with a view to providing an in-depth account of events, relationships, experiences or processes occurring in that particular instance" (Denscombe, 2010, p.52). The advantages of a case study approach are that (Yin, 2013; Elvy, 2019):

- Complex phenomena can be studied using a small number of cases (in this case participant groups of students)
- It can be used to focus on relationships and processes (which are important aspects of productive blended learning)
- It provides a naturalistic rather than an experimental setting in which to understand students' experiences (in other words based on real-life experience rather than a simulated or hypothetical setting)

However, a case study approach is not without criticism (cf. Denscombe, 2010; Golafshani, 2003; Yin, 2013). Common problems can include a lack of rigour, gaining access to case studies (including willing participants and groups), and the observer effect that can occur when participants feel like they are being monitored (Elvy, 2019). Credibility and rigour were improved in this study by using a multiple case study design over a more common single case approach (Yin, 2013). As previously stated by Elvy (2019), a multi-case approach promotes "the richness, depth and complexity that is drawn from multiple events that help one understand the phenomenon of interest that is shared among the diverse cases" (Lauckner et al., 2012, p.6). In other words, experiences might vary significantly between the two colleges in this study and even between groups within those colleges. A case is a unit of analysis which is self-contained with distinct boundaries (Denscombe, 2010). Each student group which participated in this study could be thought of as being an individual case.

The sampling and selection of cases within LCB and York Colleges was carried out using a purposive (non-probability) sampling technique. Purposive sampling is suitable for exploratory research such as this (Elvy, 2019) because it provides illustrative examples for the study of specific processes (in this case blended learning); however, the results from such a sample are not representative of a wider 'population' (Daniel, 2012) and this should be considered when comparing the experiences of other FE and HE institutions. However, the specific contexts analysed in this study can still provide insights which may inform sector wide approaches to blended learning in a post Covid-19 educational environment.

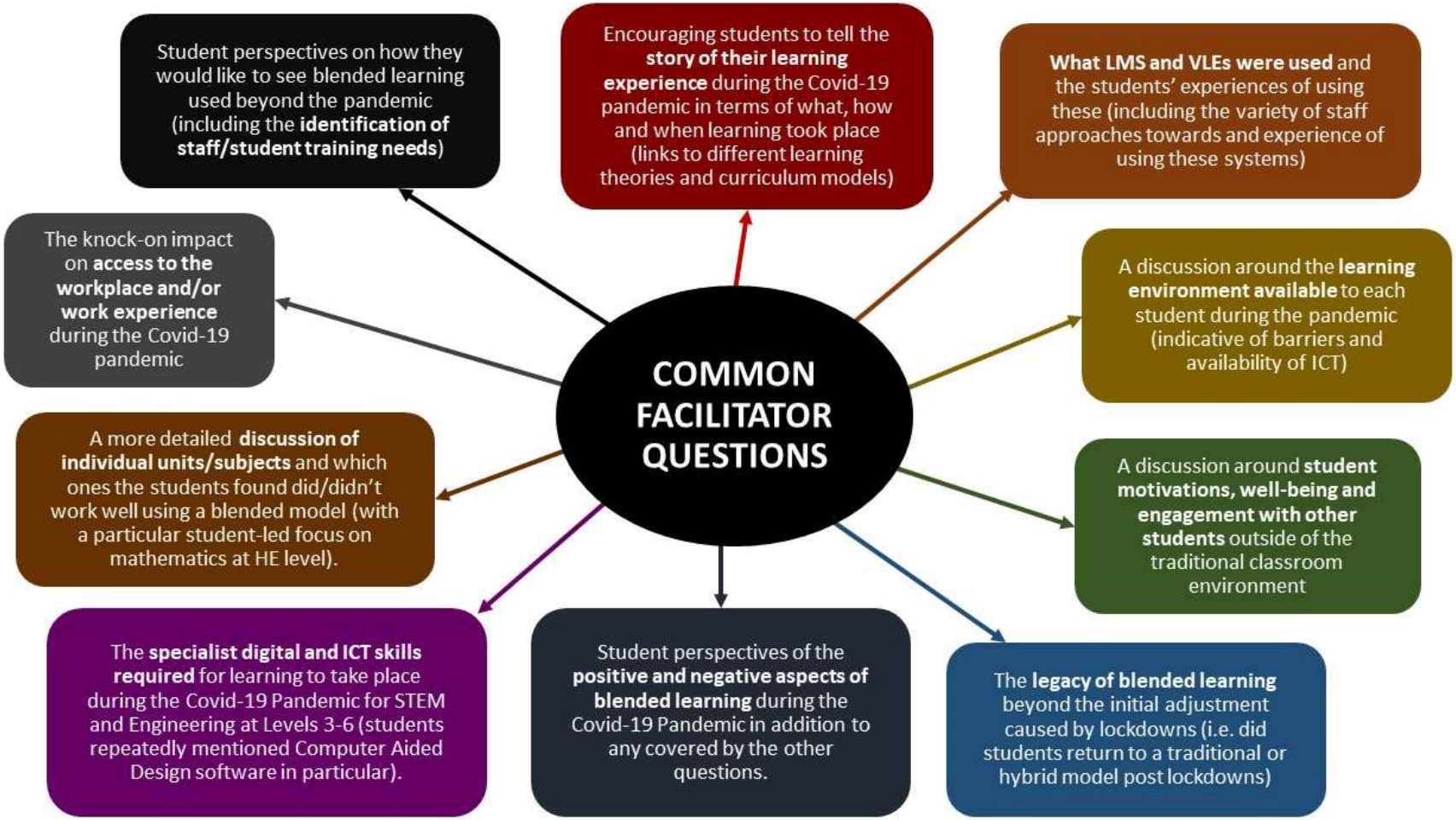
The student groups were selected from a range of level three (full time study programmes and advanced apprenticeships) through to level six (higher and degree apprenticeships) in STEM, construction and built environment subject areas. This study looked at this broad range of experiences so that the skills needed for increased progression through the levels could be identified. This was particularly important for managing the transition from Further to Higher Education. In practice, accessing a diverse range of case studies across both colleges was more challenging than expected due to the initial timing of the data collection period (occurring towards the end of the 2020-21 and the beginning of the 2021-22 academic years which were both significantly disrupted by the Covid-19 Pandemic). This meant that it took slightly longer than expected to collect and analyse the data for the depth and range of subjects and levels included in this study.

Data about student and alumni perspectives of blended learning during Covid-19 was generated from LCB and York Colleges using a series of focus groups which were held between June and July 2021 and then again between September and October 2021. Each group was facilitated by the research lead for this study and all students within a chosen group were invited to take part. A personal voice recorder was used which enabled the facilitator to re-listen to each focus group multiple times as part of the transcription, processing and analysis of the qualitative data generated. The facilitator's leading role in each focus group was to primarily listen, however a series of open questions were posed in order to generate discussion amongst the group. These questions (Figure 5.1) tended to focus on specific topics as guided by the literature review (Chapter 3) and research questions (Chapter 4).

In any study of this nature, the limitations of the method chosen have to be acknowledged and (where possible) overcome. Having initially tried to invite individual students to participate outside of their normal classes with little interest, a more successful model involved attending a

tutorial or spare lesson for the whole group. Informed verbal consent was gained before each focus group and all responses have been anonymised in this report. The limitation of this approach is that the level of engagement amongst individuals varied in each group, which made it hard to ensure that everyone was able to participate equally. This was overcome to an extent with checking and follow-on questions, for example asking for a show of hands to corroborate a specific statement made by an individual participant. Linked to this point, another common limitation of focus groups is that the narrative can be steered by a few vocal participants. One of the key roles of the facilitator in these instances was to bounce the discussion to other (quieter) individuals. Given that the discussion was focused on student experiences, the less vocal contributors in each focus group still tended to make it clear when a more vocal individual did or did not speak for them too. Some of the more vocal participants (particularly in the HE groups) were also quite good at bringing others into the discussion themselves.

Figure 5.1: A summary of the questions used in the focus groups



5.1. Research Programme

The timescales required to complete the research phase of this study (Table 5.1) were extended to enable more focus groups to take place in the 2021-22 academic year as student availability had been quite limited in the Summer term of 2020-21. This had a knock-on impact on the timing of the report writing stage which had to fit around increased teaching and assessment commitments for the research lead in 2022.

Table 5.1: Research Programme

	2021							2022								
	MAY	JUN	JUL	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	SEP	OCT
Initial scoping exercise with LCB and York Colleges																
Literature Review																
Focus Group Research (Students and Alumni)																
Evaluation (Qualitative Data Processing and Analysis)																
Report Writing																
Identification of New Blended Learning Modules																
Presentation and Ongoing Evaluation																

6. Impact of the Covid-19 pandemic during 2020 and 2021 on students' access to Further and Higher Education at LCB and York College

This section represents a descriptive general finding of students' experiences during the Covid-19 pandemic which will then feed into the more detailed analysis in the following chapters. Students spoke extensively about the sudden nature of the transition to online learning and the particular impact that multiple lockdowns had on their learning, social interactions, home life, and employment (or access to work experience). Whilst they were overwhelmingly positive about the ability of staff/colleges in general terms (and whilst they rarely acknowledged it, also themselves) to shift lessons online at short notice, students identified a broad range of impacts (Figure 6.1) which are summarised below.

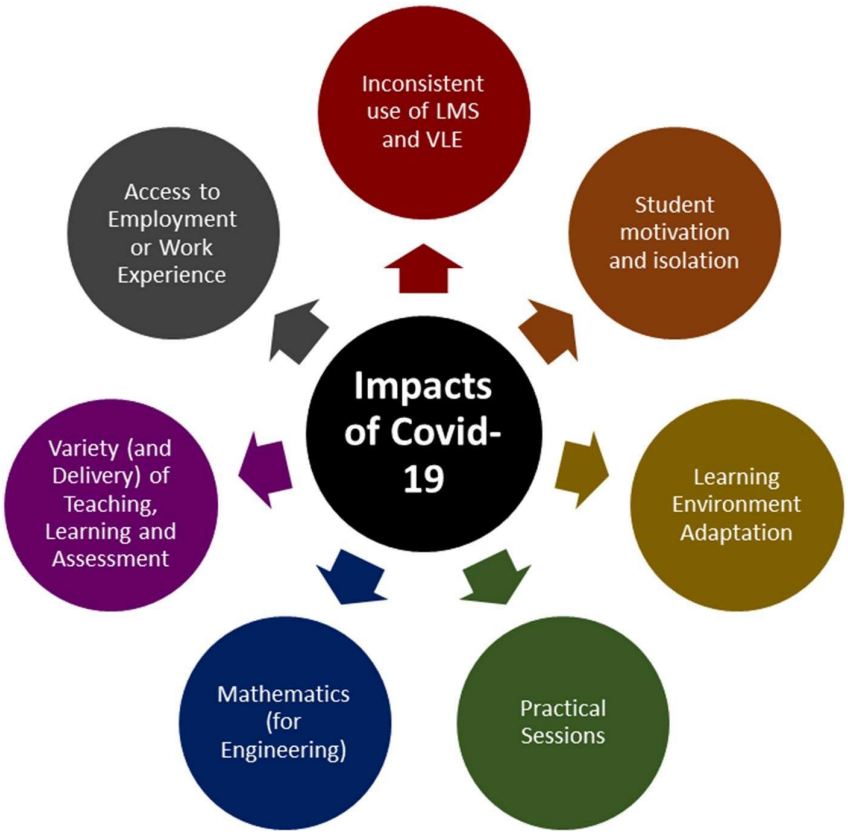


Figure 6.1: Broad impacts on students' access to education at LCB and York College during Covid-19 that were identified by the focus groups

INCONSISTENCIES IN THE USE OF LMS AND VLE: In the early months of the pandemic in particular, inconsistencies were reported into the utilisation of LMS and VLE amongst teaching staff because some used different systems to others (with Moodle, Zoom, MS Teams, and Blackboard mentioned most frequently). This also extended to the amount of time or direct access granted by some tutors online. Whilst anecdotally it was clear that both colleges worked to standardise the approach to LMS/VLE as time went on, students identified a skills gap in the ICT literacy of different tutors and called for greater consistency. This is something that any ongoing professional development arising from this study will need to address. The students in the focus groups appeared to have the resilience necessary to adapt to general changes in the use of ICT but appeared to struggle more when it came to subject specific aspects that they were unfamiliar with (see below).

STUDENT MOTIVATION AND ISOLATION: Many students (particularly those not working full time 'on-site' in construction and engineering roles throughout the pandemic) struggled with motivation and feelings of isolation during the lockdowns. Feelings of demotivation and isolation were strongest amongst Level 3 students who missed the social aspects of coming into college as well as the structured and separated learning environment. The social aspect of the student experience during Covid-19 appeared to be linked to how well they knew each other before the Pandemic as there appeared to be a stronger sense of identity and belonging amongst those who were more familiar with their classmates. However, students who joined college during the Pandemic found this to be much more challenging. Anecdotally, many students privately raised the impact on their mental health and achievement in tutorials and one-to-one discussions with their tutors during the pandemic.

LEARNING ENVIRONMENT ADAPTATION: Students of all ages and academic levels reported either having to compete for space and Wi-Fi access with multiple other members of their household, or instead turning their own bedroom into their classroom and learning environment. This included access to ICT where some people had to borrow (or even share) equipment from other family members/housemates. Many students found the lines between work, education, and home life blurred and focus group discussions focused on the strategies some students adopted to tackle this. There was some improvement in this situation once colleges reopened (although some LCB/York college students in this study continued to learn online at least some of the time because of the highly theoretical nature of the courses considered in this study. This mirrored a more cautious return to the classroom across the HE-sector as opposed to those in compulsory education and training up to 18 years old).

PRACTICAL SESSIONS: Students reported that some practical sessions (e.g., surveying) and the use of CAD software in particular were best delayed until in-person teaching resumed post lockdown because of the one-to-one support they felt that they required in order to successfully use the software when they were unfamiliar with it. There were some anecdotes of tutors trying to go to significant lengths to replicate more practical tasks including one tutor trying to do levelling in their back garden, another sharing their screen while they demonstrated CAD, and another trying to facilitate and broadcast a traffic count at a busy roundabout via MS Teams on their mobile phone. The emergency nature of the sudden shift to a fully online provision hadn't always allowed for bespoke ground-up approaches to practical delivery to emerge. There was a significant preference expressed by participants for such practical subjects to continue to be delivered in person during the 'new normal' beyond the Pandemic.

MATHEMATICS (FOR ENGINEERING): The teaching of maths online was frequently identified as being particularly challenging, especially for students who completed level 3 during the disrupted 2019-20 academic year (which contained teacher assessed (estimated) grades) and then transitioned to HE in 2020-21. The jump between level 3 and 4 engineering maths was reported to be significant and as a result learners tended to feel out of their depth because of their lack of experience/confidence. Groups who knew each other well before lockdown appeared to be better placed to provide support to each other through social media groups (e.g., WhatsApp).

VARIETY (AND DELIVERY) OF TEACHING, LEARNING AND ASSESSMENT: Given that pedagogy and learning theories weren't explicitly discussed in the focus groups, it was still possible to 'read between the lines' when trying to analyse the impact of Covid-19 and online learning on approaches to teaching, learning and assessment. For example, some students observed (as supported by Lockee, 2021) that education during the pandemic became a matter of treading water and doing what could be done within the limitations presented. Students found it easiest to engage therefore with more traditional behaviourist approaches to online learning and felt that those units that were heavy on theory or legislation (such as health and safety) were the easiest to learn online. As stated above, the more technical or practical units were received less favourably by students online and in many cases, these were carried over (to an extent) until in-person classes resumed. Students felt that the ability for individual tutors to innovate (and engage learners more actively) was dependent upon their confidence with ICT which potentially points to the need for more agile professional development within FE and HE.

Another problem identified by some of the focus groups was the repetitiveness of teaching and learning during the pandemic. Whilst this suited the learning styles of some students, others reported being extremely frustrated. For example, an anecdote which generated significant discussion and passion amongst one focus group involved one well-meaning tutor using MS Teams breakout rooms multiple times each lesson to promote active learning and group discussion without always making it clear how that fed into the bigger picture (by which they were talking about their assessment in that unit). The choice of delivery wasn't problematic *per se*, but the repetitive nature of that delivery was.

ACCESS TO EMPLOYMENT OR WORK EXPERIENCE: The experiences of students involved in this study appeared to vary significantly depending upon the programme (and academic level) of study and the nature of any employment (for those on apprenticeships). On the one hand, many of the Civil Engineering Higher and Degree Apprentices spoken to in this study remained in work and on-site throughout the pandemic and felt that the bigger adjustment came from access to online education. However, this experience wasn't universal and many apprentices in this study were placed on furlough for extended periods which increased their sense of isolation and also anxiety about completing their programme (given that many apprenticeships require evidence of work-based practice for their NVQs in the case of frameworks or End-Point Assessment in the case of standards). On the other hand, many level 3 students in full time study (e.g., T-Levels or BTECs in Construction Management) reported significant anxiety and frustration over access to the necessary work experience, even some months after the third national lockdown had ended in Spring 2021.

Having identified seven broad themes which described the most significant impacts of Covid-19 on blended learning for Level 3-6 STEM subjects at LCB and York College, the following two chapters will further analyse the lessons learned in terms of the positive aspects (value) and negative aspects (barriers) of those experiences.

7. Positive aspects (value) of students' blended learning experiences

As outlined in chapter 6, a number of positive aspects (value) to blended learning during the pandemic were identified by students who participated in the focus groups. It is important to note that not all of these impacts were felt equally by all students or indeed all focus groups, but they were all raised as positive elements of blended learning during the data generation process in this study (Table 7.1).

Table 7.1: A summary of key positive aspects (value) identified by students in the focus groups

Impacts	Key values identified
Inconsistent use of LMS and VLE	• The tools offered through the LMS and VLE used enabled students to learn flexibly which many appreciated (particularly at Level 4 and above). This was indicative of a greater level of resilience and academic experience (see Chapter 8). • Many students appreciated having recorded sessions (e.g., via MS Teams) that they could re-listen/re-watch to help them understand more difficult/technical concepts. • Whilst there were some initial teething problems, students at both colleges reported that the approach to LMS/VLE became more standardised as time went on. • The students in the focus groups appeared to have the resilience necessary to adapt to general changes in the use of ICT, but resilience shouldn't be confused for 'preference.'
Student motivation and isolation	• Students were positive and forgiving of the difficulties that both they and tutors faced in quickly transitioning to a new way of working. • Students working full time 'on-site' in construction and engineering roles throughout the pandemic seemed less affected by motivation but more by external workloads. • Blended learning still enabled some social interaction to take place. For example, some students got involved in games, quizzes, and after-hours meet ups. However, the social aspect of the student experience during Covid-19 appeared to be linked to how well they knew each other before the Pandemic. • The way in which individual staff-student conversations could take place online away from the gaze of others meant that some students felt more able to talk openly to their tutor about their mental health (see also barriers in Chapter 8).

Learning Environment Adaptation	• Some students preferred online learning, either because of the convenience or because of the reduced need to travel. There was also a sense that some more introverted students appreciated the increased anonymity. • Focus group discussions focused on the strategies some students adopted to tackle blurring of home, work, and education. A lot of students talked about going for walks, exercise or just unwinding with TV or video games.
Practical Sessions	• Blend of theory online and practical in person worked for some of the students in this study. • The anecdotes in Chapter 6 on strategies for online practical and fieldwork indicated that some tutors were willing to innovate. However, this was often limited by the technology available. • The emergency nature of the sudden shift to a fully online provision hadn't always allowed for bespoke ground-up approaches to practical delivery to emerge. It could be argued that further solutions could be found to enable some practical content to be delivered remotely.
Mathematics (for Engineering)	• Groups who knew each other well before lockdown appeared to be better placed to provide support to each other through social media groups (e.g., WhatsApp). • Some tutors provided extra one-to-one support to help those students struggling with Mathematics.
Variety (and Delivery) of Teaching, Learning and Assessment	• Some students were very positive about the innovations in the use of technology trialled by some tutors during the pandemic. The ability for tutors to engage learners more actively appeared to depend upon their confidence with ICT. • Students found it easiest to engage online with those units that were heavy on theory or legislation (such as health and safety).
Access to Employment or Work Experience	• Many of the Civil Engineering Higher and Degree Apprentices spoken to in this study remained in work and on-site throughout the pandemic and felt that the bigger adjustment came from access to online education.

In linking these positive aspects back to the academic literature, Boelens *et al.* (2017) stressed the importance of developing innovative approaches rather than simply porting existing ones online into a LMS or VLE. This was a significant challenge in reality given the emergency nature of the transition to blended learning during the Covid-19 pandemic. There was understandably some element of surviving the change rather than thriving and this was felt by students and their tutors. Focussing on this point is the key to future delivery of blended learning in Further and Higher Education, especially where more practical and technical aspects of STEM are concerned. The positive evidence that innovative approaches were developed using LMS/VLE including some quite novel practical delivery was outweighed by the fact that not all tutors were able (or in some cases willing) to do this.

In order to deliver upon the promise of blended learning post Covid-19, the communities of inquiry framework (Garrison *et al.*, 2000) is a useful tool in delivering on the promise of blended learning because an effective educational experience requires the combination of a teaching presence, a cognitive presence, and a social presence (Section 3.2). Where the students provided evidence that a community of inquiry existed, their overall education experiences were more favourable. However, the social dimension in particular was dependent upon relationships having been formed in person before March 2020. Graham's (2006) model of desirable blends is also useful for analysing the strengths and weaknesses of blended learning at LCB and York College during Covid-19 (Table 7.2). The findings in this study suggested that there was evidence of positive blends in the form of greater flexibility and depth of reflection, particularly where sessions were recorded. However, the need for greater human connection (in-person) was also highlighted, particularly for Mathematics and CAD. This supports evidence in the literature review that a blended approach is favourable over purely online or purely in-person delivery.

Table 7.2: Analysis of desirable blends (Graham, 2006) against the experiences of LCB and York College students in this study

	Online	**Face-to-face**
Strengths identified during this study	Students appreciated the more flexible approach to learning, especially when tutors had recorded the sessions (as this supported reflection). This was particularly useful when a student had missed a session due to illness or external pressures from work. Most students also seemed comfortable with the VLE/LMS provided.	Students appreciated the sessions after lockdowns where they could focus on the more technical and practical aspects of their courses, particularly where they needed one-to-one support for Maths and CAD. The Level 3 students in particular also appreciated having more structure and routine in their day and being able to spend time with friends in college.
Weaknesses identified during this study	Some students welcomed the passive and anonymous nature of online learning, but this was evidence of an undesirable blend as they would use the functionality of MS teams to 'hide' themselves away. Some people (particularly mature students and the tutors I spoke to more informally when running the focus groups) expressed frustration at sitting on Teams and seeing a wall of blank circles because many younger students significantly disliked being on camera (as this was quite intrusive).	Some students were quite content to continue learning online, although this was often reflective of external needs and pressures such as employment and reducing travel time and costs. There was a sense from some students that if they could have done the same thing online without a 2-hour (or more) round trip that they would be happy with that. However, opinions on this in the focus groups were mixed and conflicted. Another weakness related to the lack of recording of in-person sessions (which had been seen as a significant positive of online learning).

The teaching and learning frameworks and approaches adopted by LCB and York Colleges (such as LCB's CSPARr model) across academic levels 3-6 were flexible enough to enable a smooth transition between online and in-person learning. One positive aspect of blended learning during Covid-19 is that the delivery of some courses within HECDM across Construction Management, Civil Engineering and Transport Planning at LCB have continued to adopt a blended approach in the 2021-22 academic year. This was suitable for two reasons, firstly, because this approach suited the demands of specific nationwide employers who send learners to LCB from all over the country. Secondly, the highly theoretical content of STEM courses at these academic levels can lend themselves well to blended learning. However, as stated elsewhere, further consideration and professional development is required to ensure that any barriers are overcome (Chapter 8) so that blended learning provisions are not just straightforward ports of traditional in-person learning into an online space. Further consideration of how this more pedagogical transition can be achieved in relation to Strange and Gibson's (2017) reflective practice framework is given in Chapter 9.

8. <u>Negative aspects (barriers) of students' blended learning experiences</u>

As outlined in chapter 6, a number of potential barriers were identified by students who participated in the focus groups. It is important to note that not all barriers were felt equally by all students or indeed all focus groups, but they were all raised as issues at some point during the data generation process in this study (Table 8.1).

Table 8.1: A summary of key barriers identified by students in the focus groups

Impacts	**Key barriers identified**
Inconsistent use of LMS and VLE	• Inconsistent application of LMS and VLE software (different software used by different tutors for the same thing) • Inconsistent approaches to delivery via LMS and VLE (e.g., forgetting to record sessions) • Inconsistent amounts of time or direct access granted by some tutors to their students online which represented a lack of teaching presence (Hrastinski, 2019) • A skills gap in the ICT literacy of different tutors

Student motivation and isolation	• Poor student motivation and feelings of social isolation partly caused by a lack of structure and co-presence. • A lack of social networks and relationships amongst groups mostly or entirely online leading to a weaker sense of identity • Knock on impact on achievement
Learning Environment Adaptation	• Home environments not always conducive to blended learning (competition for space, focus, and Wi-Fi access with others) • Poor access to ICT and Wi-Fi • Blurred lines between work, education, and home life
Practical Sessions	• CAD and Surveying practicals delayed until in-person teaching resumed • Limitations of ICT and digital skills in enabling tutors to replicate in-person experiential learning that stimulates all of the senses (Kolb, 1984; Laird, 1985) • Preference for in-person learning to continue in the 'new normal' • Insufficient time for new curriculum models and professional development to emerge
Mathematics (for Engineering)	• Challenging online delivery • Prevalence of behaviourist and theoretical approaches • Problems with the significant jump between level 3 and 4 engineering maths • Need for quite intensive one-to-one and peer support
Variety (and Delivery) of Teaching, Learning and Assessment	• Staff and students surviving rather than thriving • Prevalence of behaviourist and theoretical approaches • Technical or practical units received less favourably online • Innovation dependent upon their tutor confidence, digital skills, and motivation • Overusing blended learning tools without thought for pedagogy

Access to Employment or Work Experience	• Balancing work and education pressures for apprentices • Isolation from college and study programme • Anxiety and frustration over a lack of work experience

In linking these findings back to the academic literature, Boelens *et al.* (2017) identified four key challenges (barriers) to the design of blended learning environments (Section 3.4). To summarise, the four challenges were:

- incorporating flexibility (i.e., student agency and identity)
- stimulating interaction (social links between staff/students and between students)
- facilitating students' learning processes (promoting self-regulation)
- fostering an effective learning climate (i.e., tackling social isolation and poor motivation)

Table 8.2 provides an analysis of how these four challenges (barriers) can be mapped against the previously identified impacts of Covid-19 at LCB and York College (Chapter 6).

Table 8.2: Mapping analysis of identified impacts against barriers to the design of blended learning (after Boelens et al., 2017)

IMPACTS of Covid-19 at LCB/York College	**BARRIERS** to the design of blended learning environments			
	Incorporating flexibility	Simulating interaction	Facilitating students' learning processes	Fostering an effective learning climate
Inconsistent use of LMS and VLE	Approaches were designed to be tutor led, mirroring Staker and Horn's (2012) more static rotation model at the expense of student-led or flexible blends as seen for example at the Open University.	Students reported significant difficulties here, because interacting directly would disrupt the flow of the lesson and lacked the spontaneity of in-person environments.	Students spoke eloquently about the impact of their tutor. The barriers identified mirror those across teaching, learning and assessment in general. Clear communication, openness and supportiveness were identified as essential.	Consistency is a critical aspect for achieving effective learning, and more work was needed to transition to a more bespoke approach to blended learning rather than the 'survival' nature of teaching and learning during Covid-19.
Student motivation and isolation	Significant levels of self-discipline are required which doesn't suit all learners and learning styles. This could be problematic where enrolment onto courses is employer led as part of an apprenticeship (or is guided by parental wishes for enrolment onto full time level 3 courses).	Some students suggested that the separation and formality of college enabled them to focus more successfully. The social dimension of college also meant that they could spend more time with friends and develop stronger relationships with their tutors.	Online learning made it much harder for students and staff to instigate incidental conversations which had a knock-on impact on understanding (particularly in terms of dynamic peer learning). Although sharing files and screens remotely was easier.	Some students faced significant challenges in establishing a comfortable learning environment. Motivation was a particular problem and some students had to spend considerable time on assignments late at night as they struggled to focus during the day.

	Incorporating flexibility	Simulating interaction	Facilitating students' learning processes	Fostering an effective learning climate
Learning Environment Adaptation	The lack of a defined and independent space and timeframe (blurring of boundaries between home, work, and education) for some learners made adjusting to online learning more difficult. Around 50% of students involved in this study had some level of difficulty accessing ICT.	Students discussed the role of breakout rooms as a tool to promote social interaction with mixed feelings. There also appeared to be a reluctance amongst students in the focus groups to engage with each other outside of lessons unless systems were already in place before the pandemic (such as WhatsApp groups).	As discussed elsewhere, there was an element of 'treading water' and surviving during the pandemic which is hopefully not indicative of a post Covid-19 learning environment. Success appeared to depend in part on the ICT literacy and confidence of the individual tutor and student concerned.	As stated above, a negative relationship existed between motivation and difficulties adjusting to studying at home. This was exacerbated by lockdowns so may be an impact that could be overcome in future (by providing students with the tools to become more resilient).
Practical Sessions	Flexible delivery of practical sessions was challenging because of the relative inexperience of learners in using specialist technical software (particularly Autodesk Revit). Some students missed out on opportunities (e.g., fieldwork) that were available before the pandemic.	Getting involved was hard for some students due to issues with Wi-Fi and technology. Quite a few students in the focus groups reported being unable to install necessary software onto their laptops due to technological limitations or employer admin policies.	It was difficult for staff to demonstrate software or live stream in order to run practical sessions (e.g., for surveying). This was seen as necessary rather than preferable. Although some students were comfortable drawing/using CAD at home if they had previous experience.	Whilst students spoke favourably of staff efforts to try and support practical delivery remotely, many reported preferring to leave this for in person delivery. When asked about post lockdown catch up sessions this was identified as the number one usage of them in Summer 2021.

	Incorporating flexibility	Simulating interaction	Facilitating students' learning processes	Fostering an effective learning climate
Mathematics (for Engineering)	As stated elsewhere, the transition to HE from Level 3 was a big step and many students felt out of their depth during the pandemic. Many students were concerned that it was hard to retain knowledge given the fragmented nature of college in general (i.e., with long summer breaks).	A lot of HE students felt that they didn't find sufficient time in the online sessions to ask questions or that important concepts weren't explained well enough. Some students felt that it was easier to help each other in class because of the efficiency of casual chat over the 'turn-based' nature of online conversations.	Many students developed coping strategies such as google and YouTube. They also tried to communicate with each other and the tutor via MS teams but felt that it "wasn't the same" as being together in a classroom.	Motivation was challenging because some students felt as if they were behind. This wasn't just a problem during the lockdowns as many HE students involved in this study still felt behind in the months following the pandemic. Catch up sessions had been offered but wider assignment pressures remained.
Variety (and Delivery) of Teaching, Learning and Assessment	There was a sense from some students in the focus groups that they would rather have watched sessions in their own time rather than having to be present at specified times. However, many acknowledged that they lacked the self-discipline to make this work in practice.	Many students reported that 'being online' during the pandemic involved listening rather than working on tasks (which were carried out at other times). Student feedback hinted at an over-reliance on behaviourist approaches and a need to combine blended learning with constructivism.	Students in the focus groups painted a mixed picture of how well different tutors facilitated students' learning. As well as the complaint in Chapter 6 about overusing technologies, other students reported finding it difficult to contact some (but certainly not all) tutors during the pandemic.	As stated elsewhere, there was a sense that students felt supported but that blended learning (predominantly online) lacked some of the personal touches (in terms of pastoral care and social engagement) that are possible in a classroom environment.

	Incorporating flexibility	Simulating interaction	Facilitating students' learning processes	Fostering an effective learning climate
Access to Employment or Work Experience	There were strong links between students, their employers (where relevant) and the two colleges in this study. As stated above, the colleges were focussed on a rotation model that suited employer demand (Staker and Horn, 2012).	One major problem identified by the focus groups was a lack of contacts in industry for some full-time level 3 students. For those already in work they sometimes really struggled to switch off given the workload (including assignments) as they felt as if they were "always on" when studying remotely.	Some level 3 full-time students expressed frustration with being able to arrange and access work experience during the pandemic. However, some of them also acknowledged that they needed to be more proactive. It seemed as if the colleges did what they could in quite difficult circumstances.	A lot of apprentices in this study discussed the challenges of furlough and for those that were more office based (e.g., Local Government officers working in Highways and Transport Planning) continued flexible working which sometimes affected their access to workplace support and guidance.

One final barrier that cut across Table 8.2. was the impact that students identified of Covid-19 on achievement and disruption to exams and assessment. Those students who faced exams as part of new or updated qualifications (such as T-Levels or the changes to the delivery of BTEC Level 3 Construction and the Built Environment) reported feeling extremely anxious about their level of understanding and preparation as a consequence of disruption to their learning during the pandemic. Those same students felt very relieved that they had not been required to sit those exams. However, as discussed elsewhere, this did seem to have a knock-on effect on the ability and confidence of those students who transitioned onto Higher and Degree Courses during the pandemic. In terms of individual achievement, this wasn't discussed openly in a focus group environment but during the pandemic my colleagues and I noticed an increase in learners struggling to achieve in a timely manner or moving onto bespoke programmes which supports the earlier work of Adams *et al.* (2015) and Powers *et al.* (2016).

9. Reducing barriers to enhance access and participation to blended learning

The previous chapter considered the negative impacts of Covid-19 on students at LCB and York College against barriers to the design of blended learning (Boelens *et al.*, 2017) which were: incorporating flexibility, stimulating interaction, facilitating students' learning processes, and fostering an effective learning climate. This chapter will further consider how these barriers can be overcome for future blended learning (BL) provisions for STEM within FE and HE. This will then lead onto a further discussion of the role of blended learning in delivering digital skills and knowledge (to enhance employability).

9.1. Better incorporation of flexibility in future BL provisions

Table 8.2 considered the relationship between the impacts identified in this study and the need for greater flexibility in FE and HE STEM provision. In practice this will be hard to achieve without significant buy in across the sector (i.e., from staff, students, and employers). Incorporating the more flexible or student-led blends highlighted by Staker and Horn (2012) would require self-discipline from students and trust from staff and employers that those students have the motivation and resilience to take responsibility for their learning. Such flexibility will appeal to those learners at higher academic levels (5 and 6) than those just starting out in their given qualification (at levels 3 and 4). In order to develop the self-discipline and resilience of students at an earlier stage in their STEM qualifications, additional training and support (outside of the taught units) could be provided. Some of the suggestions for student-centred blends that came out of this study included requests to be able to watch some sessions/videos in their own time. This might involve adopting an approach seen in blended or flipped classrooms and could certainly be an effective way of introducing fundamental concepts which are then supported with more active forms of learning once in the classroom. Another option for consideration would be to provide complementary training to introduce software which (subject to accessible ICT provision) could give students the confidence to explore new software (such as Revit and CAD) in their own time.

Considering the curriculum level of provision rather than individual topics, additional options might include exploring how students bridge different academic levels. Whilst bridging courses exist for transitioning to HE, there is a need for additional bridging once students start at Level 4. Many students spoke about the assumption from tutors that they already had the necessary skills before starting HE; however, given the long-term legacy of Covid-19 on the educational achievement of future students, this is an assumption that should be challenged going forwards. It could be argued that units such as the 'Individual Project' which is currently

provided as part of the BTEC Level 4 qualifications meet some of this demand, but is there an additional need for more ICT and practical skills support? Some HE students in this study were concerned that it was hard to retain knowledge between academic years given the fragmented nature of FE/HE study (i.e., with long summer breaks).

Finally, to reduce some of the accessibility barriers to ICT and Wi-Fi highlighted during Covid-19, colleges and universities should still aim to provide flexible study spaces beyond the classroom on site. This can enable blended learning to take place regardless of economic background, access to a productive learning environment at home, or access to equipment.

9.2. Better stimulation of interaction in future BL provisions

Stimulating interaction and active learning during Covid-19 was seen as a significant challenge by both staff and students. Intriguingly, some students spoke quite negatively about their desire for such interaction which potentially poses an interesting follow up question about what students feel like they want to get out of their learning experience. It could be argued that this is driven by a focus on results rather than the learning journey. When students did want to participate, they often felt that online learning made that harder because they didn't want to disrupt the flow of the lesson. This suggests that there is significant potential to extend the use of educational technologies in lessons so that people have the space, time, and the means to ask questions whenever they want but not necessarily in a disruptive way.

Another important consideration in removing barriers to blended learning involves ensuring that some in-person content remains. This is supported both by the literature and the findings in this study. For the more technical and practical aspects of STEM qualifications, it is useful to have a collegiate learning environment where students can support each other, both academically and socially. These strong relationships can then extend into the professional sphere beyond college/university. Working solely online during Covid-19 meant that students reported missing out on those incidental and casual conversations and learning from each other's mistakes.

Another barrier which future blended learning provisions will need to overcome is in the relationship between pedagogy, curriculum development and the implementation of online lessons. This was a significant criticism of blended learning in the literature (Cronje, 2020) and many students articulated experiences that hinted at an overreliance on behaviourist approaches to learning (i.e., listening rather than working on tasks). Unfortunately, where

tutors had very obviously tried to adopt more constructivist and active approaches, these were met with mixed feelings from the students in this study. However, this may be simply a matter of ensuring that proper scaffolding is in place for the student to see the relevance and the bigger picture of those activities.

Additional training and support might need to be made available to ensure that students are able to make the most of the digital tools available to them for social interaction with their peers during online and blended learning. Students were reluctant to engage with each other outside of lessons unless systems were already in place before the pandemic. One potential resolution to this would be to build that interaction into the assessment (as seen in the 'Group Project' unit in the Level 5 BTEC or in some Open University courses).

Finally, in order to overcome the reported ICT accessibility problems that prevent better learning interactions, more support might be required within FE/HE to ensure that students are successfully able to download and access essential software on their own computers (i.e., helping them to overcome technological, administrative or skill limitations).

9.3. Better facilitation of students' learning processes

The barriers identified relating to the facilitation of students' learning tended to mirror the challenges of providing effective teaching, learning and assessment in general. Students spoke eloquently about the positive and negative impacts of their relationships with different tutors during Covid-19. As discussed in Chapter 8, there was an element of 'treading water' and surviving during the pandemic for both staff and students which should hopefully not be indicative of a post Covid-19 blended learning environment. Developing successful staff-student relationships in part depended upon the openness, confidence, and ICT literacy confidence of all concerned. Therefore, additional staff training and student support could be made available to address this in the years ahead.

In terms of developing student resilience so that they are better able to tackle the reported problems with practical tasks and mathematics, there is a clear role for blended learning as a means of easing students into new concepts. Given that some of the more gifted students reported using coping strategies such as google and YouTube to fill a gap in their knowledge and understanding, perhaps there is space in curriculum development to provide a more bespoke set of resources that tutors teaching similar practical/mathematical subjects could share. This might be particularly useful where an individual student missed a lot of time due to illness or where they might be struggling with a particular concept. It was certainly difficult for

staff to demonstrate software or live stream practical sessions during Covid-19, but it might be easier (given the right training and support) to create and edit something that is not real-time that students can watch repeatedly.

9.4. Better fostering of an effective learning climate

This study found that establishing a comfortable learning environment was extremely challenging for many students during the Covid-19 pandemic. Problems ranged from accessing a quiet space or ICT through to student motivation and self-discipline. As stated in Section 9.1, so long as colleges and universities can provide on-site alternatives, this may help to overcome difficulties around working at home in the future (assuming that there are no further lockdowns). Aside from the space itself, additional training and support could be provided for students to build resilience, support motivation, and promote wellbeing.

From a pastoral perspective, it is important that both in-class and online provisions within a blended learning programme feature regular opportunities for pastoral support. If working practices within STEM move towards the more flexible model seen since 2020, colleges and universities will have a significant role to play in checking that their students are not feeling isolated if they are spending a lot of time working or studying at home. These opportunities can be informal as well as formal and the feedback shared by some of this author's students was that they quite enjoyed some of the optional online games, quizzes and discussions that were held outside of lesson time during the pandemic.

Another aspect of blended learning that could be useful for both students and staff is how it can be used to provide support for students with additional learning needs (including those who have fallen behind due to illness or problems with motivation and self-discipline). Opportunities could be explored for providing a blended approach where in-person catch up sessions are not practical or effective. This is something that would be most effective when planned in at the curriculum development stage (for example when producing a scheme of work). As stated elsewhere in the literature and in this study, to ensure that transitions to a blended model are successful, they must be integrated into the curriculum models (and learning theories) used in STEM courses at FE and HE. This bespoke approach will understandably require more planning than the 'survival' nature of blended teaching and learning during Covid-19.

10. Enhancing digital skills and knowledge to support better progression into the workplace

This chapter will set out the justification for enhancing the digital skills and knowledge of STEM students across levels 3-6 of FE and HE. Firstly, this will involve summarising the justification for intervention as established by the literature review and the analysis of this study. Secondly, two stages of intervention (one staff-centred and one student-centred) will be proposed, followed by a strategy for ongoing evaluation.

As previously outlined in Section 3.5, extensive educational technologies are now available and blended learning provides opportunities to utilise these technologies through innovation and experimentation. However, barriers and inequalities exist (European Commission, 2013; Bidarra and Rusman, 2017) in terms of students' accessibility to blended learning, which has a knock-on effect on their digital skills, employability and readiness for STEM and construction-related industries. Post-Covid FE and HE is well placed to modernise approaches to blended learning (Ożadowicz, 2020) and to address the digital skills gap.

Evaluation of the focus group discussions in this study found a range of digital skills and knowledge that students required more support with, particularly if STEM courses at FE and HE are to transition to a more blended approach in the years ahead. However, it is worth noting that some of these gaps extend beyond blended learning into further and higher education more broadly. The digital skills and knowledge gaps identified included:

- ICT literacy specifically relating to academic study and the production of formal (professional) documents
- Developing independent learning and critical thinking skills
- Self-motivation and resilience (including independent study outside of college)
- Self-directed software tutorials to complement learning in class, particularly for Revit and CAD
- Fundamentals of engineering mathematics to refresh and bridge the gap between levels 3 and 4 (the fact that so many students reported struggling with maths, particularly at HE levels 4 and above suggests that the problem might extend beyond the integration of maths and blended learning post Covid-19)
- Creating and maintaining professional networks, including opportunities for direct involvement (especially for Level 3-6 students not currently employed in industry) in professional body activities through student membership. For example, Level 3

Transport Planning Apprentices at LCB have a proven track record for winning the national student essay writing competition hosted by the Intelligent Transport Society (ITS UK). The principal professional bodies of relevance to the students involved in this study included the Chartered Institute of Building, Institution of Civil Engineers, Chartered Institution of Highways and Transportation, and the Transport Planning Society.

Some of the impacts (Chapter 6) and barriers (Chapter 8) concerning blended learning during Covid-19 related to tutor-student interactions. Therefore, the **first intervention** recommended by this study includes the development of continuing professional development tools and resources for tutors to enhance their use of blended learning. These should enable tutors to better facilitate the students' use of blended learning and the development of their digital skills and knowledge. A suggested mechanism for this is the development and delivery of a linear CPD programme that could be delivered as a pilot to staff who teach levels 3-6 at Leeds College of Building during the following academic year (Figure 10.1). A scheme of work would still need to be developed by the project lead and then additional staff could be brought in to help with the planning and delivery of individual sessions.

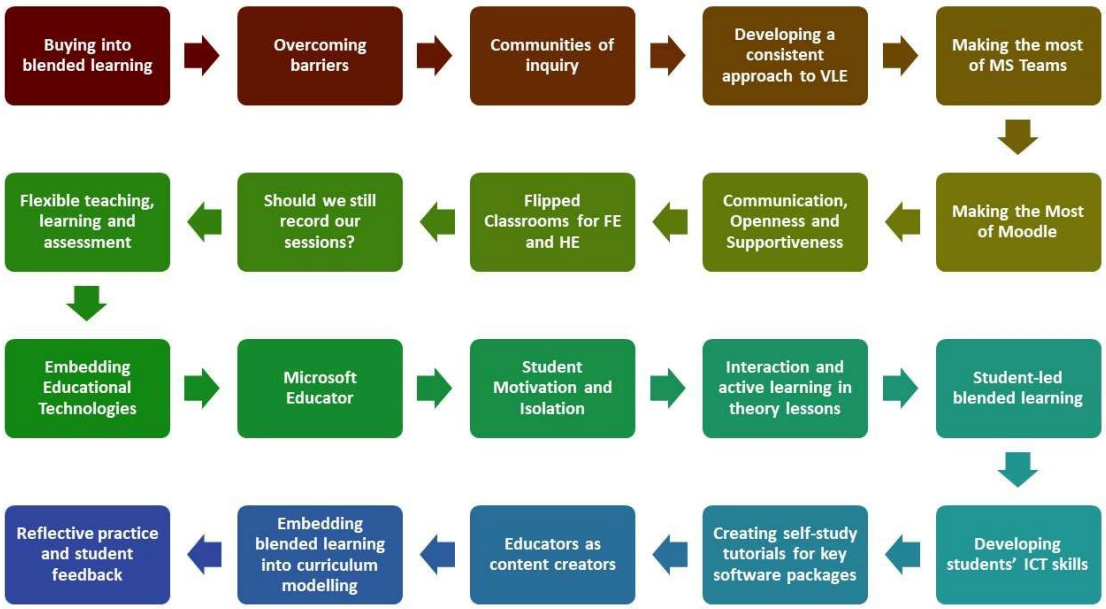


Figure 10.1: A proposed outline for a programme of training sessions on blended learning and enhancing digital skills for FE and HE staff at levels 3-6

The second intervention recommended by this study concerns the provision of a blended learning programme to support student progression into sustained employment in STEM and Construction sectors at levels 3-6. This programme would be developed to cut across full-

time Level 3 study programmes through to Higher and Degree apprenticeships given that all students need to be equipped with digital skills that will serve them beyond education and training into the rest of their career. It is important to note that some of these sessions will overlap with existing tutorial provision, so this could be integrated into that programme as part of a review of the existing scheme of work for tutorials, particularly outside of full-time study programmes. The proposed sessions (Figure 10.2) could either be delivered as a set of in-person tutorials for those groups that need them or even as an online course that could be certificated in a non-accredited way as an illustration of how continuing professional development will work when progressing to the workplace.

Figure 10.2: A proposed outline for a non-accredited course on digital skills and employability for FE and HE students at levels 3-6

A suitable method for evaluating the success of these recommended interventions is Strange and Gibson's (2017) reflective practice framework which was previously introduced in Section 3.3.2 of this report (Figure 10.3). This framework can be used by tutors and managers to map these interventions against curriculum models and learning approaches already used at LCB and York College (such as CSPARr). Undertaking reflective practice to review blended learning training methods and overall blended learning provisions at FE and HE should include continuous feedback from teaching staff and students through the normal evaluation routes. Staff involved in the development and management of the STEM curriculum (within

FE and HE) will also need to be involved in the process in order to identify how blended learning fits into the ongoing curriculum modelling process in the years ahead.

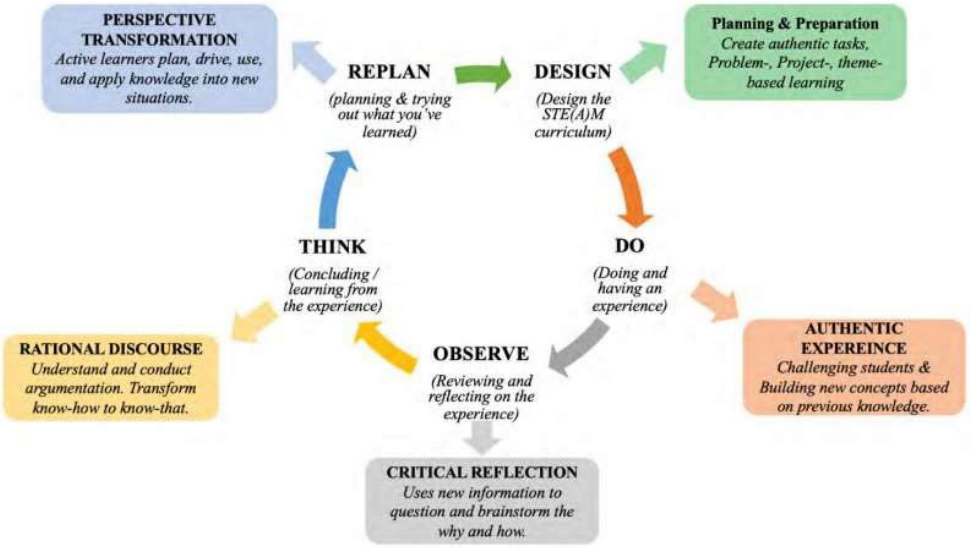


Figure 10.3: Strange and Gibson's (2017) reflective practice framework (ElSayary, 2021)

11. Summary of Key Findings

11.1. Impact of Covid-19 on students' access to FE and HE

A broad range of impacts were identified in Chapter 6 amongst students at LCB and York College. Students reported that the utilisation of LMS and VLE amongst teaching staff was inconsistent. This included the amount of time and access granted by tutors online and reflected a skills gap in the ICT literacy of different tutors. Students themselves tended to struggle more with subject specific aspects of online learning (such as CAD and engineering maths). Students reported learning maths online as being particularly difficult, particularly when transitioning from level 3 to level 4 and above. This had a knock-on impact on confidence but the presence of online peer support in some groups (via WhatsApp) appeared to be useful.

Students also struggled with motivation and isolation during the lockdowns, particularly Level 3 students who missed social aspects and the structured environment. This had an anecdotal knock-on impact on mental health and achievement amongst those groups. Some students also reported having difficulty finding a productive space to work at home due to noise and the need to share IT equipment and wi-fi access with other household members. However, this situation improved once colleges reopened. Practical sessions such as CAD and surveying were best delayed until in-person teaching resumed (demonstrating the importance of a blended rather than fully online approach). However, using online learning for more practical elements might be improved if development time is given for more bespoke ground-up approaches to emerge.

Teaching and learning approaches appeared to be more behaviourist and repetitive during the pandemic and students felt that units heavy on theory/legislation were the easiest to learn online. Innovation and engagement in lessons was dependent upon individual tutors' ICT literacy. Access to employment also varied significantly during the pandemic. Full time Level 3 T-Level and BTEC students found arranging work placements difficult without pre-existing connections. Some apprentices spent a significant amount of time on Furlough, whereas others (particularly Civil Engineering Higher and Degree apprentices) remained in work and on-site throughout the pandemic.

11.2. Positive aspects of students' BL experiences

Chapter 7 outlined the more positive aspects of students' blended learning experiences during the Covid-19 Pandemic. Positive usage of LMS and VLE included more flexible

learning and the ability to re-listen/re-watch recorded sessions, which in turn promoted greater reflection. There was also greater resilience and standardisation as time went on. Students were also positive and forgiving of the difficulties of quickly transitioning online. Some students who knew each other well pre-pandemic used the VLE to meet socially after lessons. Some students also preferred online learning due to convenience and reduced need to travel. However, others felt that it blurred the lines between home, work, and education. In terms of providing individual support to students, evidence from the focus groups found that one-to-one support was provided around mental health, maths support, and to facilitate enhanced social interactions.

The overall approach to blended learning frameworks taken by LCB and York College during the Covid-19 Pandemic demonstrated some promising innovations and evidence of positive blends that outweigh the disadvantage that some tutors are not yet able or willing to take advantage of them. This enabled a smooth transition between online and in-person learning over intermittent lockdowns and in-person periods of learning. However, in order to continue the adoption of blended learning across STEM subjects going forwards, developing innovative approaches rather than porting existing ones online will be critical.

11.3. Negative aspects of students' BL experiences

Chapter 8 reviewed the more negative aspects of students' blended learning experiences. There was inconsistent application of LMS and VLE software, delivery, ICT skills and teaching presence. This included different software being used by different tutors for the same thing. Linked to this, the limitations of ICT and digital skills made it challenging for tutors to replicate in-person experiential learning that stimulates all of the senses (Kolb, 1984; Laird, 1985). There also appeared to be a prevalence of behaviourist and theoretical approaches where staff and students were surviving rather than thriving. This also presents a danger that blended learning tools are overused without thought for pedagogy.

From the perspective of the student experience, there appeared to be a weaker sense of identity, lack of structure and co-presence which had a knock-on impact on motivation, social isolation, social networks, and relationships. Home environments were also not always conducive to blended learning and blurred the lines between work, education, and home life. Academically, students reported finding the online delivery of maths for engineering particularly challenging, especially in managing the transition from level 3 to level 4. There was some anxiety and frustration over a lack of work experience and on achievement and assessment, particularly amongst level 3 students in this study.

11.4. Reducing barriers to enhance access and participation to BL

Chapter 9 analysed how the barriers to access and participation in blended learning identified by Boelens *et al.* (2017) could be reduced.

Better incorporation of flexibility in BL provisions would require:

- Self-discipline from students and trust from staff and employers that those students have the motivation and resilience to take responsibility for their learning (mostly likely at academic levels 5 and 6).
- The ability to watch some sessions/videos in their own time that introduce fundamental concepts as seen in blended or flipped classrooms.
- Complementary training to improve ICT and practical skills, which could include giving students the confidence to explore Revit and CAD in their own time.
- A challenge to the assumption that Level 4 students are ready for HE without further support. Some HE students in this study were concerned that it was hard to retain knowledge between academic years given the fragmented nature of FE/HE study with long summer breaks.
- The reduction of accessibility barriers to ICT and Wi-Fi highlighted during Covid-19, which means that colleges and universities should continue to provide flexible study spaces beyond the classroom on site.

Better stimulation of interaction in BL provisions would require:

- Buy-in from staff and students, some of whom spoke quite negatively about wanting such interaction in this study.
- Space for students to actively participate in sessions so that they don't feel they are disrupting the flow of the lesson.
- The delivery of some in-person content because the more technical and practical aspects of STEM benefit from a more collegiate learning environment.
- Barriers to be overcome in terms of the relationship between pedagogy, curriculum development and the implementation of online lessons, particularly in terms of an over-reliance on behaviourist approaches to learning.
- Additional training and support to ensure that students can make the most of digital tools available to them, particularly in terms of engagement between students.

Better facilitation of students' learning processes would require:

- Further development of successful staff-student relationships to promote openness, confidence, and ICT literacy confidence amongst all concerned.
- Space in curriculum development to provide a more bespoke set of resources that tutors teaching similar practical/mathematical subjects could share.

Better fostering of an effective learning climate would require:

- On-site alternative study spaces to overcome difficulties around working from home in the future.
- Additional training and support to build students' resilience, support motivation, and promote wellbeing.
- Regular opportunities for pastoral and mental health support both in-class and online.
- Using a blended approach to provide additional support for students with additional learning support needs, particularly where in-person catch up sessions are not always practical or effective.

11.5. Enhancing digital skills and knowledge to support better progression into the workplace

Chapter 10 outlined digital skills and knowledge gaps that students required more support with. These included: ICT literacy; independent learning and critical thinking skills; self-motivation and resilience; self-directed software tutorials to complement learning in class for Revit and CAD; fundamentals of engineering mathematics; and creating and maintaining professional networks, including opportunities for direct involvement. In order to address this, two interventions are recommended: the development of a linear CPD programme of twenty sessions for tutors to enhance their use of blended learning; and a non-accredited course on digital skills and employability for FE and HE students at levels 3-6 made up of sixteen modules/tutorials that could be delivered in-person or online. The success of these pilot interventions can be evaluated using Strange and Gibson's (2017) reflective practice framework, which would involve continuous feedback from both staff and students in the sector.

12. Development of New Blended Learning Activities and Materials to support progression

Chapter 10 identified two interventions, one staff-based (Figure 10.1) and one student-based (Figure 10.2) that could be used to support the progression of Level 3-6 STEM students into the workplace using blended learning. This section provides some more detailed suggestions of indicative content (Tables 12.1 and 12.2) that could form the basis for each of the individual modules/sessions. Individual institutions and tutors will then be able to use this to produce bespoke training to meet their own students' needs (in terms of the identified skills and knowledge gaps in each context).

The staff/student focussed modules could be woven into existing training and support, or alternatively as a new non-accredited provision using a mix of in class sessions and an online VLE similar to the one successfully adopted by the Microsoft Innovative Educator programme. The amount of study time allocated to each module will depend upon local priorities and available time at each institution, although conceptually each module has been designed to take around 60-90 minutes to complete. As stated in Chapter 10, the staff-focussed blended learning modules (Table 12.1) would work best as a linear structure as it makes a case for blended learning and then considers how it could be implemented in practice. Alternatively, the student-focussed blended learning modules (Table 12.2) might work better on the basis of student-identified need, subject to each STEM student at levels 3-6 completing a minimum number of modules overall (as a form of educational CPD).

Table 12.1: Indicative content for staff blended learning modules

No.	Module Name	Indicative content of the modules
1	Buying into blended learning	• Exploring the myths and realities of blended learning • Tutor roles in creating and enabling supporting blended learning environments
2	Overcoming barriers	• Impacts identified during Covid-19 (overview of existing research including this report) • Incorporating flexibility (How blended learning could be more student-led or flexible, the role of independent space, and how knowledge can be better retained between sessions, courses, and years). • Stimulating interaction (Enabling spontaneity, facilitating relationships with and between students, the role of activities and breakout rooms, and the importance of questioning). • Facilitating students' learning processes and fostering an effective learning climate (The tutor's role in blended learning, bringing openness and supportiveness online, maximising the benefits of online and offline spaces, the learning environment, motivation, and personalisation, maintaining pastoral care and social engagement)
3	Communities of inquiry	• Theory and background • Teaching presence (interaction with clear goals and direction) • Cognitive presence (students actively learning) • Social presence (student engagement with each other) • Social-Cognitive Interactions (supporting discourse) • Social-Teaching Interactions (setting climate) • Cognitive-Teaching Interactions (regulating learning) • Analysing the strengths and weaknesses of blended learning (desirable and undesirable blends)
4	Developing a consistent approach to VLE	• Consistent application of LMS and VLE software (ensuring that all tutors use the same systems) • Consistent delivery via LMS and VLE (setting agreed principles for usage such as the length of sessions and use of recordings) • Consistent access to tutors (so that students are clear about when and how to access one-to-one support from tutors)
5	Making the most of MS Teams	• Overview of key features • Managing groups and files • Using specific tools and functions (would be bespoke to the group/software but could include tools like MS Forms) • Embedding educational technologies (see also session 11)
6	Making the most of Moodle	

7	Communication, Openness and Supportiveness	• Creating safe, open, and supportive learning environments • Promoting openness through positive role models • An open door isn't the same as being on call 24/7…
8	Flipped Classrooms for FE and HE	• Theory of flipped learning and flipped classrooms • To flip or not to flip • Advantages and disadvantages • Dealing supportively with students who don't engage
9	Should we still record our sessions?	• Exploring the advantages and disadvantages of recording sessions • What do students gain from recordings? • Exploring alternatives (e.g., pre-recorded revision material)
10	Flexible teaching, learning and assessment	• What flexibility means • Who is flexibility for? • How flexible teaching, learning and assessment could work • Why adopt a flexible approach? • Evaluation
11	Embedding Educational Technologies	• Overview of relevant educational technologies • How to embed these into existing teaching, learning and assessment
12	Microsoft Educator	• Overview of the Microsoft Educator Programme • Registration • Suggested sessions to try

13	Student motivation and isolation	• Fostering an effective learning climate
		  ○ Providing and nurturing safe spaces
		  ○ Providing communities for learning
		• The importance of enrichment on the rest of the curriculum
		• Student self-discipline, resilience, and work-life balance

14	Interaction and active learning in theory lessons	• The value of active learning in theory lessons • Helping students to understand the bigger picture (why am I doing this?) • Breaking the ice: how to overcome students' reluctance to get involved (particularly online)

15	Student-led blended learning	• How can blended learning promote student enquiry and curiosity? • Why flexible approaches to blended learning (e.g., Open University) work well for some students and not others • Embedding flexibility in your own teaching
16	Developing students' ICT skills	• Developing students' ICT skills for academic study and professional writing • Developing independent learning and critical thinking skills • Evaluating the specific needs of your students (e.g., software tutorials or refresher courses in engineering mathematics)
17	Creating self-study tutorials for key software packages	• How self-study tutorials can complement in-class teaching, learning and assessment • Existing vs. bespoke tutorials • Identifying key packages (e.g., AutoCAD, Revit) • Ensuring students can access software and files • Tutor support
18	Educators as content creators	• Experimenting with social media and video • Potential tools and approaches • Keeping it brief and engaging • Video editing for beginners
19	Embedding blended learning into curriculum modelling	• Evaluation of existing approach to curriculum modelling • Intent, Implementation, Impact • Curriculum models: product, process, and praxis • Using a praxis model to embed blended learning
20	Reflective practice and student feedback	• Introduction to the reflective practice framework • Involving students in reflective practice • Critical reflection of assumptions • Critical reflection of knowledge • Critical reflection of experiences

Table 12.2: Indicative Content for student digital skills and employability modules

No.	Session Name	Indicative content of the modules
1	Know your reps, cohort, and tutors	• An opportunity to get to know each other and the tutors which could take the form of a more informal team building session or enrichment activity.
2	Academic and professional writing	• Word (and open-source equivalent) hints and tips • Answering the question • Formatting • Writing concisely and in the third person • Embedding diagrams and charts
3	Presentation skills	• Advantages and disadvantages of different approaches • PowerPoint (and open-source equivalent) hints and tips • Less (text) is more • Design approaches • Embedding media
4	Study skills and resources	• I do it because I want to, not because I have to • Time management and avoiding procrastination • Research and reading • Paraphrasing and summarising • Referencing • There's more to life than Google: An overview of online databases and journals
5	Independent learning	• These three modules could run as a series looking at more advanced study skills for progressing to higher education and employment. • The indicative content would explore strategies for developing greater independence and resilience during academic study. • Also ties in with module 11 (productive learning environments)
6	Critical thinking	
7	Self-motivation and resilience	

8	Professional bodies and CPD	• Overview of relevant professional bodies • Making the most of professional bodies • Membership • Networking • Events and competitions
9	Networking and professional social media	• Keeping your CV up to date • Overview of professional social media • Making the most of LinkedIn • Getting involved in employer marketing • Continuing Professional Development
10	Making the most of the VLE	• This will need to be specific to the approach adopted by each department/institution. • Module contents will focus on topics such as: navigation, accessing resources, assessment, and collaboration

11	Productive learning environments	• This module would ideally provide an interactive forum which focuses on enabling students to work out what works best for them in terms of:
		  ○ Study time
		  ○ Study location
		  ○ Work-Life balance and mental health
		  ○ Time management

12	Creating and using group networks	• Using social media productively and responsibly (professional practice) • Collaboration rather than collusion • Inclusivity • Open vs. closed networks (e.g., MS Teams vs. WhatsApp)
13	Fundamentals of engineering maths support	• The intention of this module would be to provide additional reassurance and support for those that find the step up from level 3 to levels 4 and above difficult. Many departments will do this already. • This could include online examples and quizzes for students to self-evaluate their own skills.
14	CAD/Revit troubleshooting	• As with the previous module, this could supplement existing courses to provide additional support and reassurance. • If tutors were to utilise or develop online practicals to support in-class learning, these could be utilised here.
15	Exam writing for FE and HE	• Structuring your exam time • Providing an initial outline and then more detail • Don’t forget study skills from other assessments

16	Note taking, why bother?	• Value of notetaking in theory and practical sessions • Explanation and demonstration of relevant techniques (e.g., the Cornell method) • Value of diagrams and sketches

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