# The use of videoconferencing and low-latency technologies for instrumental music teaching

Benjamin Paul Redman

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I was admitted as a research student at the Royal Conservatoire of Scotland and the University of St Andrews in September 2014.

I received funding from the Royal Conservatoire of Scotland and have acknowledged the funder in the full text of my thesis.

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# Abstract

Videoconferencing platforms have been used for a number of years in the UK and other countries to facilitate instrumental music lessons between remote parties. However, videoconferencing is typically not optimised for music performance which results in poor audio quality and musicians not being able to play together. Prior to the COVID-19 pandemic, this led to some resistance to using the technology.

Low-latency technologies such as LoLa and JackTrip offer high-quality audio and facilitate synchronous musical interaction so that remote parties can play music together in real time. However, limited research has been conducted on how effective these technologies are when used for instrumental music teaching. This study aimed to address this gap through the following research questions:

- What changes in the quality of the interactions and the learning and teaching experience between face-to-face, standard videoconferencing, and low-latency environments?
- Are some elements of music instruction more or less effective in these different environments?
- What are the barriers to using these technologies in educational settings, and how can these be overcome?

I deployed a mixed methods concurrent nested design. My research was primarily qualitative and conducted through a series of small-scale trials, interviews, and autoethnographic studies, together with analysis of data from a larger set of LoLa trials in three European conservatoires, and a small-scale quantitative study. Participants included music teachers and students in Higher Education and school settings across a range of instrument types and musical genres.

Several themes emerged from a synthesis of the findings across the 17 studies, including: teachers' attitudes became more favourable to the various technologies after trialling them; the visual element of technologies was important for musical cues and diagnosing technical and postural problems in students; each learning environment had its own advantages and disadvantages, but participants preferred the face-to-face environment.

My research makes an original contribution to literature by reporting findings showing that: playing together can form a significant element of face-to-face lessons, LoLa and JackTrip low-latency technologies improved musical interactions compared to standard videoconferencing platforms, LoLa can be used in conjunction with an institutional firewall, JackTrip can be used with multiple players on domestic internet connections.

I conclude that low-latency technologies have an important role in the future of music education by offering increased interaction between teachers and students from different institutions, and by offering new teaching and learning possibilities, including collaborative learning, and teaching through playing.

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# Abbreviations

ABRSM: Associated Board of the Royal Schools of Music

ADC/DAC: Digital to analogue conversion/analogue to digital conversion

BGP: Border gateway protocol router

bpm: Beats per minute

DAW: Digital Audio Workstation

FPS: Frames per second

GARR: Gruppo per l'Armonizzazione delle Reti della Ricerca,
the Italian national computer network for universities and research

Gb: Gigabit

HE: Higher Education

HEI: Higher Education Institution

HMEI: Higher Music Education Institution

Janet: Joint Academic Network, the UK national computer network for universities and research

LoLa: Low-latency audiovisual streaming

Mbps: Megabits per second

MOOC: Massively open online course

MP3: MPEG-1 Audio Layer III, a coding format for digital audio

ms: millisecond

MS: Microsoft

NMP: Networked music performance

NREN: National Research and Education Network

PA: Public address system

PDF: Portable document file

RCS: Royal Conservatoire of Scotland

TPACK: Technical Pedagogical and Content Knowledge

VoIP: Voice over Internet Protocol

Wi-Fi: Wireless fidelity

# Preface

E.M. Forster's novella, *The Machine Stops*, first published in 1909, imagines a dystopian society in which humans live in subterranean rooms, connected to each other via 'The Machine':

> […] the round plate that she held in her hands began to glow. A faint blue light shot across it, darkening to purple, and presently she could see the image of her son, who lived on the other side of the earth, and he could see her (Forster, 1909/2011, p.2).

> There were buttons and switches everywhere - buttons to call for food, for music, for clothing […] And there were of course the buttons by which she communicated with her friends. The room, though it contained nothing, was in touch with all that she cared for in the world (Forster, 1909/2011, p.6).

The 'Book of the Machine' provides instantaneous answers to questions, and many people shy away from direct human contact and instead communicate via 'the machine'. Despite being written over a century ago, there are some obvious parallels with our recent experience of lockdowns during the COVID-19 pandemic, with the Internet being a leading source of information, and synchronous visual communication being mostly mediated via videoconferencing. In the novel, Kuno (the son of the main protagonist) protests that 'the machine' has 'robbed us of the sense of space and of the sense of touch, it has blurred every human relation' (Forster, 1909/2011, p.33).

Humans are innately social, and we experience a biological need to bond with and co-operate with each other (Greenberg and Gordon, 2020). For the vast majority of hominid history, social communication has consisted of face-to-face interactions with others from the same tribe; familiarity was built up through hunting and foraging together, through recognising their micro-expressions, their pheromones, and the totality of their being (Sapolsky, 2016). Thus, our primate brains are not hardwired for the loss of familiarity

when our social interactions are mediated via technology and removed from all the other senses that create our impressions of another person.

Music plays an important role on a biological level of making us feel human, and is a cultural practice that is universal across all societies, dating back at least 40,000 years (Greenberg and Gordon, 2020). Music may have been essential to our pre-linguistic ancestors (Mithen, 2009), strengthening group cohesion in hunter-gatherer times by signalling bonds and shared values in tribal groups (Greenberg and Gordon, 2020). Research has shown that when singing together, our brains produce oxytocin, a hormone linked to synchronising with others and forming social bonds (Carter, 2014).

In comparison to the many millennia that humans have been making music together, the phenomenon of learning, rehearsing and performing music with others via videoconferencing and low-latency technologies is a very recent development. Similar to Kuno in *The Machine Stops*, there has been a sense from many that learning music via these new technologies detaches us from the authentic experience of making music together. This thesis aims to explore the quality of the experience for teachers and learners in these different environments.

# Chapter 1: Introduction

This chapter provides information on the background of the project, the rationale for choosing the project, and some detailed information on what each study in the project contains. It is structured in seven sections: music in education, and the benefits of music; a short history of videoconferencing; an explanation of latency and how it affects musicians; current practices and context in instrumental music teaching; personal context; aims and research questions; and an outline of the thesis structure.

## 1.1 Music in education

There is a wealth of research reporting on the multi-faceted benefits of music education on children's cognitive, academic, social, emotional and physical wellbeing (Črnčec et al., 2006; Hallam, 2010; Department for Education, 2011; Susino, 2020). Research also points to the benefits on mental health and wellbeing through lifelong engagement with music (MacDonald et al., 2012; Simones, 2015).

For some music students in Western societies, the pinnacle of musical education is studying at a conservatoire with a highly respected performer-teacher through regular one-to-one lessons. The conservatoire gathers expert teachers and learners together in one institution and facilitates opportunities for playing together. However, a growing body of research suggests that the one-to-one lesson should be repositioned within a wider context of creative activities that better reflect the professional activities of the 21st century musician (Creech and Gaunt, 2012). Hasikou (2020) argues that due to a combination of rapidly advancing technologies and a shift in pedagogical attitudes, new approaches to one-to-one lessons should be considered in music education.

A report by the Scottish Government in 2015 on delivering instrumental music lessons in schools recommended that 'Local Authorities should complement individual and group instrumental music tuition and explore the huge

opportunities arising from the use of technology to enhance the delivery of a 21st century instrumental music service' (Instrumental Music Implementation Group, Scottish Government, 2015, p.26). The report provided examples of the use of videoconferencing in one-to-one and group instrumental music lessons in Dumfries and Galloway, where students were being taught in remote locations that had not previously had provision of instrumental music lessons. An evaluation team from Warwick University noted through observation that: 'Pupils appear to be making progress on a par with or better than they would have done in "normal" instrumental lessons' (Huddleston et al., 2007, p.11).

Even before COVID-19, in a time of increasing financial austerity in Scotland, school and Local Authority instrumental music services were particularly vulnerable to cutbacks and increased charges for students, resulting in inequalities in access to music provision (Broad et al., 2019). Instrumental teaching via videoconferencing therefore seemed to offer attractive possibilities in delivering instrumental music lessons as teachers could teach from one location without the expense and loss of contact time associated with travelling between schools, and reach schools and students that would not otherwise have access to instrumental lessons (Prior et al., 2015).

During the early stages of my research, I discussed the use of videoconferencing with the Head of the Junior Department of the Royal Conservatoire of Scotland (RCS). Whilst there was no firm policy of using videoconferencing, it was reported that Skype lessons were used 'opportunistically' to reach students in remote areas who struggled to attend weekly face-to-face lessons at RCS. I also discussed videoconferencing with the Head of Guitar and Harp at RCS. They described how their department had used the 'eStaccato' videoconferencing platform (now since discontinued) to conduct remote auditions and keep in touch with students who had auditioned and were waiting to start courses at RCS.

Despite the apparent advantages of videoconferencing, it was not widely used in education until March 2020 when, in response to the COVID-19 pandemic,

schools, colleges and Higher Education Institutions (HEIs) across the world made a rapid pivot to teaching online. Musicians and music educators sought to continue learning, rehearsing, and performing together by using and adapting existing technologies. Many music teachers who had never previously taught online turned to videoconferencing, but quickly realised its limitations and looked for technologies that would allow them to perform together remotely. Social media forums were flooded with questions from teachers asking how to play together with students in online lessons. And therein lies one of the biggest challenges in teaching instrumental music lessons online: standard videoconferencing platforms and networks are not yet sophisticated enough to allow synchronous playing together. Low-latency technologies offer the possibility of synchronous musical interaction but, as yet, they are not widely available, affordable, accessible, or reliable.

## 1.2 A short history of videoconferencing

The first telephone call was made by Alexander Graham Bell in 1876. Five decades later, the first demonstration of a 'video conference' occurred in 1927, when the head of the AT&T corporation spoke to the then U.S. Secretary of Commerce, Henry Hoover, using a two-way audio connection and a one-way video connection (Orr, 2020). Videophone booths were launched by AT&T in 1964; the product failed, but development continued, though confined mostly to corporate services as the technology was expensive to deploy. Advances in internet technology and improvements in video codecs led to the launch of the US company WebEx in 1995 and videoconferencing became more widely available, though at this time it was mostly used for business (ibid).

In 1998, Polycom developed high-quality audiovisual streaming hardware called ViewStation, featuring a pan-tilt-zoom (PTZ) camera, along with codec and communications electronics (Contavespi, 1998). However, the hardware was expensive, it required a high-capacity network, and there was considerable latency in the system. The Skype platform, launched in 2003, was free and available to download on Windows and Mac platforms. There

were a reported 50 million users in 2005 with the release of Skype 2.0, increasing to more than 600 million in 2010 with the release of Skype 4.1. Skype was further developed for use on mobile platforms in December 2010 (Cowling, 2016).

Pioneers in the use of videoconferencing for music teaching were the Manhattan School of Music (MSM), with the launch of the first videoconference programme at a US conservatoire in 1996 (MSM, 2021). In 1997, violinist Pinchas Zukerman held a master class from the Manhattan School of Music with students at the Hong Kong Academy of Performing Arts. In 1999, MSM expanded its Arts-in-Education programme to include students in New York City schools and, in 2003, developed a course offering students training in developing outreach programmes via videoconferencing. In 2005, MSM collaborated with Polycom to create 'Music Mode' videoconferencing designed for music education (MSM, 2021) offering high-quality audiovisual streaming, but the system has considerable latency and expensive hardware and infrastructure requirements.

Institutions such as the Manhattan School of Music have been forward thinking in using videoconferencing technology to collaborate with international partners, expanding their outreach to include schools, and providing training for students in using the technology for teaching. However, the adoption of videoconferencing technology has been dependent on affordability of the equipment, and the speed and capacity of an institution's network. In the education field, 'Teleconferencing' became increasingly widely used with medical students for Continuing Medical Education (Lamba, 2011) but videoconferencing was not more widely adopted until the advent of free-to-use platforms such as Skype.

A major drawback with free-to-use videoconferencing platforms is that they are designed for speech interaction rather than musical interaction. This presents technical challenges for musicians attempting to perform synchronously via videoconferencing due to latency, poor audio quality, and the effect of 'switching', where the videoconferencing software applies echo

cancellation to mute one person while another person speaks (Iorwerth et al., 2015).

## 1.3 Latency

Latency refers to the natural delay in sound emanating from an instrument or singer and reaching another player's ears. Latency is measured in milliseconds (1 ms = 1/1000 of a second); sound travels through air at approximately 1 foot per ms, depending on atmospheric conditions. It is observable in normal acoustic situations where larger spaces are involved, such as when a choir located behind an orchestra has to sing promptly so that its sound does not appear to the audience to lag behind that of the orchestra (Redman, 2020). The greater the latency, the greater the effect of a player waiting for the sound of another player to respond, who is in turn waiting for the sound of the first player, which can cause the tempo of a piece of music to slow down from the 'recursion' effect (Chafe et al., 2010).

There is some debate in the literature as to how much latency musicians can tolerate before synchronisation with each other is compromised. Chafe et al. (2004) report on an ideal 'sweet spot' of 11.5 ms with a moderate amount of latency beneficial to performance synchrony; Gurevich et al. (2004) report orchestral musicians being comfortable playing with a latency threshold of up to 35 ms; a recent paper (Tsioutas and Xylomenos, 2021) suggests that musicians in Networked Music Performance (NMP) environments are tolerant of one-way delays of up to 40 ms. However, from my own experience and anecdotally, other factors that affect a musician's tolerance to latency include tempo and genre of music, the acoustic qualities of the performance space, and perhaps most importantly, the experience and adaptability of the musicians.

Latency in computer audio is affected by a variety of factors. Data travels at approximately 70% of the speed of light across fibre optic cables. The greater distance between performers, and the greater the number of network segments and relay points (i.e. network hops) that the fibreoptic cables

carrying the audio signals over the Internet have to make, the greater the signal latency. Another factor is the home network connection, with fibre-to-the-home being fastest at about 2 ms, and cable or DSL (Direct Signal Line) being the slowest at about 10–15 ms. The bandwidth of a home user's network service plan does not necessarily correspond with latency, with audio packet jitter (the time delay in the sending of data packets over a network connection) being affected by the smoothness of data flows and network congestion. Wi-Fi routers can add significant latency and jitter (in excess of 10 ms), with wired connection via an ethernet cable sometimes being less than 1 ms (JackTrip Foundation, 2021b).

Further latency challenges arise from computer hardware. For example, the sound card or audio interface determines the amount of latency from analogue to digital (ADC) conversion and digital to analogue conversion (DAC). This can vary widely between manufacturers, with specialist music studio applications usually having the lowest latency. Further acoustic latency is added depending on the distance between each user's microphones and speakers (ibid.).

## 1.4 Current practices and context in instrumental music teaching

Research into instrumental music teaching is a 'relatively new field of enquiry' (Burwell, 2012, p.77), but as Gaunt (2010) notes, there has been more recent growth in research relating to instrumental and vocal teaching in Higher Education, and a body of scholarly literature now exists in this area. Research into online music teaching is an even more recent development, and according to Koutsoupidou (2014, p.244), 'relevant studies only appeared after 2000'. Johnson (2021, p.1) reports that 'online semester-length music courses have been offered at an exponential rate of increase since 2012' at universities in the United States. The COVID-19 pandemic has created a sense of urgency in adapting traditional music teaching practices to the online environment.

There is a comparatively limited amount of literature concerned with instrumental music teaching via videoconferencing, and most of the available literature reports on small-scale interventions and case studies; hence, it is difficult to make generalisations from these studies. However, those studies that do exist suggest that not being able to perform together due to issues of latency and software is an issue for teachers (Dammers, 2009; Koutsoupidou, 2014; King et al., 2019; Kruse et al., 2013; Shoemaker and van Stam, 2010).

Low-latency technologies are still in their infancy compared to videoconferencing, but systems such as LoLa and UltraGrid were designed to address the problem of latency by offering an audiovisual streaming system that allows synchronous real-time interaction over large distances (Drioli et al., 2013; Ubik et al., 2016). However, there is minimal published research on how effective these tools are when used in educational settings, and the available literature suggests a need for more in-depth testing (Riley et al., 2014; Davies, 2015; Iorwerth and Knox, 2019).

An array of low-latency technologies is now available for musicians, ranging from audio-only platforms such as JackTrip, JamKazam and Jamulus, through to full audiovisual streaming platforms such as LoLa and UltraGrid. The choice of which platform to use is affected by a number of factors including expense, accessibility, usability, and reliability. I have chosen to focus my research on two systems, LoLa and JackTrip.

LoLa-enabled PCs and the required specialist cameras and peripheral equipment demand a significant financial investment by an institution, as well as requiring infrastructure support and maintenance. It is therefore important for institutions to understand the capabilities and limitations of the technology before making this investment. JackTrip, a low-latency audio-only software program, has recently been made available to work on standard networks using inexpensive standalone devices, which offers an alternative platform to LoLa, but without the visual element.

## 1.5 Personal context

I first used videoconferencing for receiving lessons in pipe band drumming via the Skype platform from a teacher based in Glasgow in 2010. The most obvious benefits of learning via videoconferencing were the convenience and saving of time and travel costs. The picture and sound quality on the Skype platform were poor and the network connection was unstable, but despite the difficulties, I was able to make musical progress and gain some valuable professional development. I was intrigued by the possibilities this new medium offered, particularly for learners such as myself in remote locations without easy access to specialist teachers. In addition to the convenience of not having to travel, I was also aware of the benefit to the environment.

Since my teens, one of my dreams was to study vibraphone at Berklee College of Music in the USA. Taking regular lessons in vibraphone in the UK was previously problematic as there are very few professional jazz vibraphone players in the UK, let alone Scotland, and journeys to London for face-to-face lessons involved taking two days out of my schedule, plus travel and accommodation costs. I began taking lessons in vibraphone via videoconferencing in 2011 and I was able to study with top players from around the world, including a teacher at Berklee College of Music, and in so doing, achieved one of my earlier goals.

Thus, something that was previously prohibitively expensive and time-consuming became easily accessible via videoconferencing. However, the sound quality was poor using the Skype platform, with the sound of the vibraphone often distorting to the point of being painful to listen to. Another major drawback, especially in a jazz context where interaction in real time is an important element, was not being able to play together via videoconferencing.

Despite the problems of audio quality and latency, I realised that teaching via videoconferencing had enormous potential to transform the process of how musicians learned, as well as widening access to different styles and genres

of musical learning, and I subsequently decided to explore this via a research degree at the Royal Conservatoire of Scotland. Despite my own enthusiasm, I soon found that videoconferencing was not met with universal acceptance or approval. When I first discussed my research into music lessons via videoconferencing with colleagues, many were dismissive, with comments including: ‘you can't teach music via videoconferencing’, ‘it's not the same, it doesn't work’, and ‘this will put us all out of a job’.

Shortly after beginning my doctoral research at RCS, I discovered low-latency audiovisual streaming (LoLa) was being used in the music department of Edinburgh Napier University. At that time, LoLa was a relatively new technology and not widely known about or used. The possibilities of being able to perform synchronously were immediately obvious to me and low-latency technologies became the focus of my research.

During my research, I requested to trial online learning including videoconferencing and low-latency technologies at schools in my Local Authority. My request was turned down for a number of reasons, including concerns about the safeguarding and supervision of students, data security, and possible reputational damage to the Local Authority. However, this decision was rapidly reversed following the first COVID-19 lockdown introduced in the UK in March 2020, when my teaching colleagues and I were asked to teach students online, without much guidance and no clear plan. Fortunately, I was already experienced in teaching online, but many colleagues found the experience stressful.

In some respects, recent events have overtaken part of this research as videoconferencing is now accepted for teaching instruments in schools, and music services are now far better prepared for online instrumental music teaching. However, as I will argue throughout this thesis, low-latency technologies have the potential to transform instrumental music teaching by facilitating remote synchronous performance.

## 1.6 Aims and research questions

There is currently limited research on the use of low-latency technologies in music education. My research seeks to analyse the responses of a variety of music teachers, students, and other stakeholders using videoconferencing and low-latency technologies to facilitate instrumental music lessons remotely, and to assess the extent to which low-latency technologies improve the experience of the teacher and student over standard videoconferencing platforms.

This research is therefore timely as it aims to provide an evidence base to inform policy and decision making of Higher Music Education Institutions (HMEIs), Local Authority music services, schools, and individual teachers in assessing the opportunities, benefits, and limitations of low-latency technologies for music instruction.

The research questions are:

- Research question 1: What changes in the quality of the interactions and the learning and teaching experience in lessons between face-to-face, standard videoconferencing, and low-latency environments?
- Research question 2: Are some elements of music instruction more or less effective in these different environments?
- Research question 3: What are the barriers to using these technologies in educational settings, and how can these be overcome?

The studies presented here investigate different groups of teachers and students to give a broad view of the use of videoconferencing and low-latency technologies in instrumental music learning and teaching. Participants were drawn from beginner level to conservatoire level, and from different instrument disciplines including voice, piano, woodwind, brass, strings, percussion, and guitar. Musical genres range from classical music through to jazz and popular music, Indian classical and Scottish traditional music, to the more recent genre of Networked Music Performance, where musicians interact in real-time via the Internet.

## 1.7 Structure of the thesis

The thesis is structured in nine chapters as follows:

- Chapter 1 outlines the whole research study, providing information on the background of the project, the rationale for choosing the project, and some detailed information on what the study entails.
- Chapter 2 contains the literature review, which will be used to underpin the theoretical framework that is developed further in Chapter 3. The literature examined includes studies on learning theories, instrumental music teaching, online learning and teaching, and technology. Literature relating to the effect of the pandemic on education is also discussed.
- Chapter 3 contains an outline of the research paradigm and details the research methods used, along with considerations of validity, biases, and ethics.
- Chapter 4 contains the results of studies into videoconferencing, including interviews with practitioners and students, a study into the frequency with which teachers play together with students in face-to-face lessons, and a survey of music teacher responses to teaching during the COVID-19 pandemic.
- Chapter 5 contains the results of autoethnographic studies using videoconferencing from my own dual perspective as teacher and learner, as well as discussions on becoming part of an online musical community, informal learning, and MOOCs.
- Chapter 6 contains results of the initial LoLa trials, an observation of LoLa used for synchronous remote recording, and an interview with a director of distance learning at a world-leading orchestra training establishment.
- Chapter 7 contains results of a larger-scale evaluation of LoLa used in three European conservatoires.
- Chapter 8 contains results of a trial with JackTrip low-latency audio-only technology, together with interviews with practitioners.
- Chapter 9 is the concluding chapter and provides sections containing a summary of answers to the research questions, a synthesis of themes emerging from the studies, the contribution to literature, limitations and future research areas, and implications of the research.

# Chapter 2: Literature review

## 2.1 Introduction

The aim of this chapter is to survey and summarise key sources in the existing academic literature, identify the gaps that exist in current knowledge, and to formulate research questions that respond to those gaps. The chapter is organised in seven sections. Following the introduction, I review selected literature on learning theories. I then survey literature relating to the three main intersecting discipline areas of my research: instrumental music teaching; online learning, including music; and technologies to support music learning. I survey literature relating to low-latency technologies, and the recent upheaval in education caused by the COVID-19 pandemic. In the final section, I discuss a critical analysis of the gaps found in the academic literature, which provides the rationale for my research questions. My professional and research background is in music education, and this provides the foundation for this review.

## 2.2 Learning theories and teaching frameworks

### 2.2.1 Introduction

In this section, I first outline three classic theories of general subject learning; I then examine three theories developed more recently for general online learning; I move on to examine the problem of applying these theories to the complex domain of music learning; and finally I explore a more recent teaching framework developed by Johnson (2020) that combines elements of these models for teaching music online in the Higher Education (HE) environment.

### 2.2.2 Learning theories

Harasim (2012) describes three classic learning theories that have been developed to describe and analyse the process of learning: behaviourism, cognitivism and constructivism. Behaviourism was established by Pavlov

(ibid.) and incorporated ideas of conditioning and a belief that behaviour was independent of conscious control. Cognitivism analyses the cognitive processes that enable learning and how learners interpret their experiences and environment, with the learner now considered to be active in the learning process. Constructivism views learners as being involved in a process that creates and constructs meaning, and promotes active learning or 'learning by doing' (Harasim, 2012, p.92).

Taetle and Cutietta (2002) discuss these theories applied to music learning but note that music is also its own unique domain and not necessarily subject to the same processes that apply to general learning. They acknowledge that music is a 'complex and interwoven matrix of skills, knowledge, affect, and beliefs' (Taetle and Cutietta, 2002, p.292), and that a diverse range of theories are required to explain different phenomena in music learning. Furthermore, as noted by Seddon and Biasutti (2009), instrumental teaching practice is its own domain within the overall subject area of music. Other models of learning do not readily translate to this environment, and studio practices 'should be approached and understood on their own terms' (Burwell, 2018, p.21).

Colwell (2011) states that the 'instructivist' or 'direct instruction' approach to skill acquisition is a particularly effective model to describe instrumental music learning and teaching. Colwell describes direct instruction as having six teaching functions:

1. Daily review
2. Presenting new material
3. Guided student practice
4. Feedback
5. Independent practice and/or homework
6. Review (Colwell, 2011, p.95)

In this model, the teacher establishes the tasks and continually assists students by making corrections to posture and technique, and decides when mastery has been achieved and the student is ready to move on to the next

task. There are many benefits to this teacher-centred approach, as students are taught skills ‘correctly’ and provided with practice opportunities, and the teacher can frequently check for understanding and performance mastery. Clear goals are set and achieved, and the model is therefore particularly well suited to the early stages of learning an instrument. However, being overly dependent on a teacher is increasingly critiqued in the later stages of learning and will be discussed in Section 2.3.2.

Harasim (2012) examines the development of online learning and also relates it to the theories of behaviourism, cognitivism and constructivism. Harasim proposes a new theory of ‘online collaborative learning’ (OCL) to include ‘discourse, collaborative learning and knowledge building’ (Harasim, 2012, p.92) that provides students with the ‘resources and kinds of activities that will help them to build knowledge collaboratively, using the Internet’ (Harasim, 2012, p.97). However, Singh (2014) argues that Harasim’s theory of OCL is merely an extension of constructivism, in that OCL facilitates the construction of knowledge.

Connectivism is described by Siemens as a ‘learning theory for the digital age’ (Siemens, 2005, p.1); the theory proposes that learning occurs through connection, and uses the power of online networks and networking to facilitate learning. The study of connectivism directly resulted in the development of the first Massively Open Online Course (MOOC) in 2008 (Downes, 2020). There is some evidence for the success of connectivism, including increased motivation on the part of students due to increased self-management and self-efficacy (ibid.). However, as with OCL, there is criticism of connectivism as a concept, with some scholars viewing it as merely an extension of existing theories (Sánchez Cabrero and Costa Román, 2018).

### 2.2.3 Teaching frameworks

Koehler and Mishra (2009) describe a framework for integrating technology with teaching titled TPACK, or technology, pedagogy, and content knowledge. The introduction of new digital technologies presents challenges to teachers,

as each technology has its own potentials, affordances and constraints that make them more suitable for some tasks than others. Furthermore, social and contextual factors may complicate the task of incorporating technology with teaching: teachers may have inadequate experience of technologies, and schools and HEIs may be unsupportive of facilitating appropriate training. Therefore, teachers may feel unprepared and under pressure when trying to incorporate learning how to use another tool into an already busy teaching schedule.

There are complex interactions between technology, pedagogy, and content knowledge, and it is essential for teachers to understand how learning and teaching may change when particular technologies are used in particular ways (Koehler and Mishra, 2009). For example, videoconferencing is a relatively easy technology to deploy, but it does not facilitate playing together, which affects how teachers deliver and structure their lessons, and the content they use. Conversely, low-latency technologies do facilitate playing together, which affects delivery, structure, and content of lessons, but the technology is not so available or easy to deploy. My research addresses these areas.

Gall (2017) discusses the TPACK model applied to the training of music teachers in England. Gall refines the TPACK model and makes a distinction between general pedagogical and technical knowledge, and music specific pedagogical and general knowledge. Different domains of musical knowledge include performing, creating, and responding to music, and technologies can be used to support learners in acquiring skills and understanding in each of these domains (Bauer, 2014).

Andrews (2011) acknowledges that the term ‘e-learning’ is itself controversial (Andrews, 2011, p.107), but dismisses the term ‘technology-enhanced learning’ on the grounds that learning and technology are not entirely separate: technology can enhance learning, but it can also hinder, and the two are therefore reciprocal and coevolutionary. For example, teachers adapt their teaching methods to cope with the technical deficiencies of standard

videoconferencing platforms. Andrews proposes that ‘e-learning’ is distinctive from ‘learning’, and argues that e-learning is not merely an extension of contemporary learning theories, but rather it requires a new theory of learning, as it changes the nature of learning in four ways:

- As a psycho-social construct, e-learning is socially situated, and e-communities are different from conventional communities in classrooms. E-learning requires more from the student as they have to make selections from the available resources and decide how and when to engage with the learning.
- The epistemological nature of knowledge is affected by digital technology, with less of a hierarchical relationship between existing knowledge, the teacher and the student, and a more democratic and potentially dialogic relationship.
- Digital technologies facilitate greater ease of ‘transduction’ of knowledge from one form to another; for example, from digital score to recorded artefact for teachers and students to share.
- Learning is always subject to access opportunities, and difficulty of access can be further exacerbated in the e-learning realm due to socio-economic, geographic, cognitive and motivational factors (Andrews, 2011).

Johnson (2017) discusses the adoption of a social-constructivist framework for online music course design in the higher education environment. The social-constructivist model incorporates elements of constructivism along with the social element of interacting with others and a scaffolded learning model. This framework is further developed in ‘A conceptual model for teaching music online’ (Johnson, 2020), in which different elements are considered, including teaching approaches, ways of learning (including the three classic models previously outlined), the online environment, and student skills and knowledge. In common with Taetle and Cutietta (2002), Johnson acknowledges that teaching music is complex and while a single model can be helpful by offering processes to assist teachers in the construction of online music teaching, it should not be overly restrictive and stifle artistic freedom to achieve authentic music learning (Johnson, 2020).

As the literature surveyed shows, there is not, as yet, one overarching model that adequately accounts for instrumental learning and teaching via remote methods. It is worth noting that in my experience of attending in-service teaching development training over a number of years, learning theories have never been discussed. This may be because instrumental music teaching is considered a niche and specialist area. There is clearly an opportunity here for further work in this area, especially in light of the new reality of COVID-19, and the need to develop robust methods of online instrumental music teaching.

## 2.3 Instrumental music teaching

### 2.3.1 Introduction

This section discusses a selection of literature in the interrelated contexts and settings of one-to-one lessons in conservatoires and schools and group learning. Three key professional sources for teaching younger students are also reviewed, along with literature relating to playing with others and the development of timing.

Research into instrumental music teaching is a ‘relatively new field of enquiry’ (Burwell, 2012, p.77) and, as reported by Mills (2007) and Zhukov (2007), there is a general lack of research into instrumental music learning and teaching strategies. However, Gaunt (2010) notes a recent growth in research relating to instrumental and vocal tuition in Higher Education, and a body of scholarly literature now exists in this area. There is less research literature pertaining to instrumental teaching in schools, though a canon of practical literature exists from professional organisations and authors. The conservatoire model has influenced how instrumental music lessons are delivered in schools but, more recently, there has been a move towards group teaching and the incorporation of informal learning practices at all levels of education.

### 2.3.2 The one-to-one lesson in conservatoires

In addition to studio lessons, conservatoires also offer a range of rehearsal and performing opportunities, as well as supporting studies. However, studio lessons, based on the one-to-one or master-apprentice model, are a foundational part of conservatoire music education. The apprenticeship model has a long tradition in instrumental music education and is found in many different musical cultures (Gaunt et al., 2021). Burwell (2013, p.276) writes that the model is a 'richly-textured and complex practice' and while difficult to define precisely due to the wide variety of contexts in which it is found, there are some common assumptions about what the practice entails, including the acquisition of skills, knowledge and experience; the master positioned as an authority and a representative of the practice; the master demonstrating and the apprentice imitating; the complex relationship between the master and apprentice (ibid.).

There are many benefits and advantages of the master-apprentice model, including allowing for a highly personalised approach directly tailored to the individual needs of the student (Burwell et al., 2019), and 'the opportunity for a depth of encounter that would provide a student with firm technical and artistic foundations for their career and a relationship with the teacher that they might treasure for life' (Duffy, 2016, p.378). Students often admire and respect expert teachers, and value their authority (Maidlow, 1998).

Zeltsman (2003) describes how learning intensively for several years with one specialist teacher has a 'purity' of approach which can keep a student focussed, but it may also require the student to accept certain premises and principles on trust. Students may also choose to take occasional opportunities to study with different teachers, which can lead a student to gaining a broader view of their specialisation. However, it can sometimes be difficult to reconcile different approaches to specialist study, which may lead to students becoming confused and disheartened. Therefore, when faced with sometimes conflicting information and opinions from different teachers, students have to make their own judgments as to which approach is best.

Despite the master-apprentice model being so prevalent in classical music education, it has been described as 'remarkably unsystematised and unregulated' (Gaunt et al., 2021). The model is increasingly being critiqued for its potentially dominating and authoritarian teaching methods (Gaunt, 2008; Renshaw, 2010; Zhukov, 2012; Zhukov and Sætre, 2021). There can be the possibility of an 'over-directive approach' with imbalanced, and potentially damaging, power relationships (Duffy, 2016), with students potentially playing a more passive role in the learning process (Creech and Gaunt, 2012; Gaunt, 2010; Zhukov, 2007). By its very nature, the one-to-one lesson takes place in isolation and is thus inaccessible to others, leading to a cloistered environment for the student (Burwell et al., 2019).

The isolation of the one-to-one studio lesson may also be detrimental to the professional development opportunities of teachers. Many instrumental teachers are expert performers and yet have limited training in instrumental music pedagogy (Gaunt et al., 2021; McPhee, 2011). Furthermore, despite being the mainstay of conservatoires, many teachers are part-time (Duffy, 2016), and they may have difficulty accessing continuing professional development opportunities (Creech and Gaunt, 2012). Therefore, teachers may rely largely on their own personal background and experience, and teach in the way in which they themselves were taught (Burwell et al., 2019). Instrumental teachers may also find it difficult to ask for advice from teachers in the same institution, preferring instead to seek advice from teachers in different institutions (Duffy, 2016).

Creech and Gaunt (2012) argue that individual one-to-one lessons remain a valuable part of the conservatoire experience, but the one-to-one lesson should be repositioned within a wider context of creative activities that better reflect the professional activities of the 21st century 'portfolio' musician. More recently, there has been a shift from teacher-centred to student-centred learning, and conservatoires have been using group-based learning (Zhukov and Sætre, 2021), and borrowing activities from popular music pedagogy such as collaborative and peer learning (Renshaw, 2013). Students may also have more than one studio teacher and participate in masterclasses that

‘complement or challenge’ their principal teacher’s approach (Burwell et al. 2019, p.17). Students are increasingly being encouraged to engage in self-directed learning and self-regulation, as well as critical thinking (Gaunt et al., 2021).

Gaunt and Westerlund (2013, p.1) argue that collaborative learning is ‘becoming one of the most powerful ways to deal with the challenges of development in music and higher music education’. These include co-operating beyond geographical boundaries and meeting new social situations and navigating cultural difference (ibid.). They also argue that collaborative learning allows for reflection on the values and ethics in higher music education. They cite more recent research by Wenger et al. (2002) into the social dimensions of learning through communities of practice, that help develop expertise through a wider horizon of learning possibilities.

Zhukov and Sætre (2021, p.1) describe a ‘teaching-through-playing’ approach to developing a student’s musical and social skills through collaborative chamber music instruction, and advocate for ‘broader conceptions of musical communities of practice’ in preparing graduates for professional work (ibid, p.4). However, they also note that it is important to match the skill levels of participants when working in group settings, something that may be a challenge in a small conservatoire.

Gaunt and Westerlund posit an approach that goes beyond ‘making what has previously been done more effective, but also in creating vision, extending pre-existing realities through reflection and challenging established forms of education and expertise in our field creatively and constructively’ (Gaunt and Westerlund, 2013, p.3). They describe how collaborative learning can take place in many contexts in addition to group tuition, including one-to-one lessons, peer-teaching, distributed networks, and mentoring. An example is co-teaching, which can facilitate possibilities for learning and teaching beyond the vertical structure between teachers and students; there are also peer-learning opportunities in the horizontal plane between students, and also between teachers, thus giving a richer experience for all (Clauhs and Newell,

2013; Zanner and Stabb, 2013). The need for greater support and training for conservatoire teachers has been recognised by the establishment in 2006 of the Innovative Conservatoire (ICON) to scrutinise and develop established pedagogies (Duffy, 2016).

### 2.3.3 The one-to-one lesson in schools

From a survey undertaken in 2001 with 134 school-based instrumental music teachers in England (Mills, 2005), many teachers believed that the characteristics of effective teaching were different between Higher Education and school settings, though the following six characteristics were shared between the two settings: the teacher is knowledgeable; the teacher is a good communicator; the teaching is matched to what the students need; the teacher is positive and praises students; the teacher provides plenty of opportunities for the students to perform; and the teacher gives plenty of attention to the development of instrumental technique (Mills, 2005).

Four characteristics of teachers that were considered to be more important in schools than in Higher Education were that the teacher should be enthusiastic, inspiring, patient, and that ‘lessons are fun for students’ (Mills, 2005, p.87). This concurs with Harris (2012), who suggests that in the early stages of learning an instrument, teachers should be more focussed on nurturing and encouraging students, and less concerned about technical and musical achievements.

Mills (2005) discusses the occasions of moments of ‘revelation’, when a student’s progress suddenly takes a leap forward. These moments were often reported as coming from masterclasses and group lessons where students learned from each other. The importance of playing with other students, as well as playing for other teachers in a masterclass situation, is becoming increasingly recognised and is discussed in Sections 2.3.5 and 2.3.6.

### 2.3.4 Three key sources as practical methods for teaching younger students

Given that private studio teaching is unregulated, and that instrumental music teaching in schools is not governed by the same professional entry requirements as classroom teachers, there is a need for a body of professional literature for instrumental teachers, and three key sources are discussed in this section. They differ from the research literature by providing practical advice for instrumental music teachers working in schools or private practice, from the 'what' to teach, as well as the 'how' and 'why'.

The first source is *A Common Approach* (Federation of Music Services and National Association of Music Educators, 2002) which sets out a generic framework for structuring instrumental music lessons. This document was produced following a two-year consultation process with leading authorities on instrumental music teaching, including the Associated Board of the Royal Schools of Music (ABRSM), several UK conservatories and universities, and various Local Authority music services. It sets out a curriculum at a national (UK) level for different families of instruments, and also sets out a holistic approach to learning and teaching, encompassing six areas identified in the generic framework:

- developing instrumental and vocal technique;
- listening to and internalising music;
- creating, developing, and interpreting musical ideas through improvisation and composition;
- playing music by ear, from memory, and by sight;
- performing with others;
- interpreting and communicating the character of the music, including pupil self-evaluations of their own performances.

The framework is a key source for instrumental music teachers working in schools and private practice, and was adopted by the London Borough of Newham to structure their 'Every Child a Musician' (ECaM) instrumental curriculum (Welch et al., 2014). While comprehensive in its scope, A Common

Approach is not exhaustive, but nonetheless serves as a useful blueprint for designing a rounded instrumental music curriculum.

The second key professional source is *Instrumental teaching: a practical guide to better teaching and learning* (Hallam, 1998), which provides a scholarly discourse on many of the pedagogical, philosophical, sociological, and psychological factors associated with instrumental music teaching. These include processes of learning, the teaching environment, and understanding musical ability in students. Hallam's stated aim is to provide instrumental music teachers 'with an understanding of human learning and how to promote it in their students' (Hallam, 1998, p.xv) which it achieves with clarity and insight, drawing on Hallam's considerable experience as a professional musician, teacher, and psychologist. As well as exploring some of the theoretical underpinnings of instrumental music teaching, Hallam explores a wide range of issues, including the use of technology. Hallam states:

> It [technology] is part of the musical future and we will be letting our students down if we do not attempt to integrate it into our teaching. However, to teach well requires that the teacher is confident in using the resources and believes in their value (Hallam, 1998, p.315).

This is a theme that will be returned to later in the thesis, as teacher attitudes are one of the most important elements of successfully implementing new technologies.

The third source referred to is *The Virtuoso Teacher* (Harris, 2012). This adds to the professional canon but serves more as an 'inspirational guide' as opposed to a prescriptive text, and explores the technique of teaching, and the importance of the relationship between the teacher and student. Harris discusses the connection between the 'virtuoso performer' and the 'virtuoso teacher' as having the same highly developed skills of communication, technique, artistry, and imagination, but wryly observes that 'great players don't always make great teachers' (ibid., p.90). Harris also discusses the use of the Internet as a tool for finding up-to-date information and resources, and,

somewhat presciently, asks the question, ‘will we be giving lessons online sooner or later?’ (ibid., p.91).

### 2.3.5 Group learning

The development of group teaching in schools could be viewed as being driven more by financial and administrative imperatives than by pedagogy (Harris and Crozier, 2000). However, as discussed by Welch et al. (2004) and Mills (2007), there are robust pedagogical and social reasons for students learning together in groups with the possibility of performing with, and learning from, other students.

Harland et al. (2000) discuss school students deriving personal and social development from engagement with the arts in general, and in music there were perceived effects relating to awareness of others, social skills, and wellbeing. Group music making helps develop team-working skills (Hallam, 2015) and can also contribute to feelings of social inclusion (Minguella and Buchanan, 2009). Research at the Barbican-Guildhall campus into creative and group learning found that ‘participants took part for a variety of reasons, including developing artistic skills, valuing the collaborative working process of ensembles, developing friendships and the transferable skills gained’ (Gregory and Renshaw, 2013, p.29).

There is a consensus in the literature that learning and performing together with other musicians in groups can help students develop social skills and personal development, but these are perhaps peripheral to the musical experiences to be gained from peer learning and group interaction. Swanwick (1996) states that these include critical assessment of peers, and music being learned and performed in a social context. He suggests that learning from peers of a similar age can be a stronger motivation for learning than from a teacher by recognising peer achievements and having the consolation of recognising peer difficulties.

Simones (2015) reports mixed feelings amongst Higher Education students about the value of group teaching, with some expressing frustration: 'Group sessions are a waste of time — you are learning stuff about other people's performances that don't apply' (Simones, 2015, p.3), through to a recognition of their value:

> I didn't like the idea of having to perform in class for my colleagues, but now I realise just how important that was in understanding not only my own performance, but also in learning loads about what is involved in playing other musical instruments and in performing different music styles (Simones, 2015, p.5).

Ley (2004) summarises group teaching as being most effective when: there is a framework for teaching and learning; students are allowed to listen, perform, compose and improvise and appraise their own and others' work; and each student is appropriately supported within the group (Ley, 2004, p.22). This concurs with the framework identified in *A Common Approach 2002* (Federation of Music Services and National Association of Music Educators, 2002), and it is posited that group learning forms an important part of music learning and teaching.

### 2.3.6 The importance of playing with others and the development of timing

Welch et al. (2014) report that in the most effective instrumental music lessons, students have opportunities to perform alongside their teachers, to observe modelling of techniques and repertoire, and to practise these behaviours themselves and also simultaneously with others. Kokotsaki and Hallam (2011) report that by performing in groups, musicians gain 'opportunities to develop a wide range of skills that were perceived to be of value to them in pursuing a career in music'. They go on to state:

> Considering the positive effects of ensemble playing participation on the musical, personal and social development of non-music students, music educators should encourage their students' participation in musical ensembles by providing opportunities for

> participation in performing groups as often as possible with special care taken over appropriate groupings and style of instruction taking account of level of attainment and motivation (Kokotsaki and Hallam, 2011, p.168).

Given that learning to play with others is an important part of a musician's development, it therefore follows that developing a musician's sense of timing is essential to allow them to perform with others. Gabrielson defines timing as 'the duration of the sound events, as well as of 'non-sound' events (rests or silences)' (Gabrielsson, 2000, p.29), and acknowledges the complexity of different aspects of timing such as tempo, rhythm, articulation, and 'deviation from mechanical regularity' such as with a Viennese waltz, where the second beat is played fractionally early (ibid., p.48). Pouthas writes:

> Music is commonly said to be the art of time. It is clear that the development of musical competence is partly related to the development of temporal competence: perception of duration and rhythms on the one hand and temporal regulation of actions on the other hand (Pouthas, 1996, p.115).

Rasch defines synchronisation in musical performance as the way in which 'musicians manage to coordinate their own temporal (onset) structures with those of the other performers, in such a way that the temporal structures actually match each other and fuse into one common temporal structure' (Rasch, 2000, pp.70–71). For various reasons including tone production, spacing between players and environmental acoustics, the accuracy of synchronisation in performances can vary and 'there will always be some degree of asynchronisation' in a performance (Rasch, 2000, p.71). Nonetheless, the development of individual time perception is an ongoing concern for all musicians.

Kirschner and Tomasello report on a study suggesting that children were better able to play along to a beat on a drum played by an instructor rather than a mechanical device or a recording. They hypothesised that this may be due to: perceived motivation through social collaboration with a partner; and also through better understanding the task through its representation by the

experimenter, and the ‘joint attention’ of both on the same task, which ‘allows an individual to better anticipate the behaviour of the other’ (Kirschner and Tomasello, 2009).

Thus, playing with others is an essential part of the musical learning experience, and the development of timing is an important facet of this experience. The ability of online learning to facilitate this essential area of musical development will therefore determine the effectiveness of online methods for instrumental music teaching.

### 2.3.7 Informal learning

According to MacDonald et al. (2017), music can be a channel through which people construct personal and social identities, and can be used to express thoughts, emotions, and beliefs. Musicians may also construct their identities in many different ways: through formal education, through informal means, and for many, a mixture of both (López-Íñiguez and Coutts, 2020). In the seminal book *Music, informal learning and the school: a new classroom pedagogy*, Green (2008) describes how bringing informal practices from popular music learning into the school music classroom can bring fresh perspectives to classroom teaching.

The Internet is awash with informal music education content via blog posts and platforms such as YouTube. In addition, there are numerous subscription-only resources available as short courses with downloadable PDFs, backing tracks and supporting videos, and interactive music webinars where participants can type comments in a chat feature for the teachers to respond to during a webinar. However, the quality of the online material is widely variable and because of the proliferation of online media content available to musicians at all levels, students can be overwhelmed in deciding which content to consume. A teacher can therefore be extremely helpful in directing students to quality media at a level appropriate to their stage of development.

YouTube has become part of the digital landscape since its inception in 2005. Wise et al. (2011) report that students have used YouTube in conjunction with formal classroom learning in a variety of ways, including: composing and recording songs and then uploading them to YouTube; using YouTube to find material to support performance skills and research musical concepts and music history; and providing performance examples of pieces students may be working on in class. This aligns with comments from Teacher A (Chapter 4, Section 4.2.3) on giving students historical contexts for different stylistic developments.

In my own teaching, I frequently direct students to YouTube videos that demonstrate musical concepts or are classic examples of particular musical styles or genres. For example, when students begin learning the Bossa Nova rhythm on drum kit, I will often play a YouTube clip of the Astrud Gilberto recording of *The Girl from Ipanema*, or when a student begins timpani studies, a short video excerpt of the final movement of Beethoven's Ninth Symphony (Op.125), which can be helpful in demonstrating timpani in the context of an orchestra.

The power of having almost instant access to audio and video materials cannot be overstated. I studied music at sixth-form college in the pre-Internet age; part of the final exam required me to perform standard orchestral percussion excerpts, including the snare drum part of *Overture Pique Dame* by Franz von Suppé. I wanted to listen to the recording to hear the snare drum part in context and to practise along to the recording. It took me several weeks to track down a recording, whereas now, within seconds of searching online, I can access at least five YouTube videos demonstrating the snare drum part to *Overture Pique Dame.*

When learning a new piece of jazz repertoire, I will listen to as many versions of a tune as possible and try and learn the melody and chords directly from recordings, rather than sheet music in a 'fake' or 'real book', which are notorious for containing errors. Repeated listening helps to internalise music

leading to deeper learning. I also turn to recordings to learn different players phrases, also known as ‘licks’, a common method of learning jazz language.

A commercial jazz education website offers free access to live YouTube streaming ‘guided practice’ sessions, where a teacher demonstrates a musical concept, and then invites audience participants to practise in ‘real time’ along with the teacher (without their camera or microphone switched on). Participants are able to interact with the teacher through the text chat facility on YouTube.

## 2.4 Online education, and technologies to support music education

### 2.4.1 Introduction

Online education has a large and well-developed field of literature, and whilst it is important to acknowledge it, I have purposely kept this introductory section brief, so as to focus more fully on emerging technologies in online music education that are more relevant to this study.

As reported by Bowman (2014), distance education has an extensive history dating back to correspondence courses of the early 20th century, through educational television programmes of the 1950s and later, up to online courses from the 1990s to the present. Distributed learning is a more recent term that has subsumed the term ‘distance learning’ and is characterised by learning that allows teachers, students, and content to be located in geographically different places and at different times. There is a lack of consistency between the terms ‘e-learning’, ‘online learning’ and ‘distance education’ in the research literature, which has implications for the referencing and sharing of research (Moore et al., 2011). Andrews (2011) defines e-learning as learning mediated by electronic means, including online and offline methods, and Bowman (2014, p.5) refers to online learning as ‘learning that takes place partially or entirely over the Internet’.

The benefits of online learning discussed by Watson (2014) include increased flexibility of time and place of learning; greater ease of sharing information and resources; a more enriching learning experience on a local, national and international level; greater equity of access for students disadvantaged by location, social or disability reasons; and the development of digital literacy. Disadvantages include limited access to software and hardware for financial reasons, thus making it not entirely equitable; network access restrictions; specialist knowledge or training required to operate some hardware or software; and information overload due to the sheer volume of information available.

Writing in 2014, Watson also notes differing attitudes among teachers, with some viewing online education as a natural progression to their practice, some being interested but unsure how to begin, while another group may be reluctant to change. Therefore, time, training and resources are necessary for teachers to develop expertise in online education, but as events in 2020 have shown, online learning is now part of the educational landscape at all levels, and has become an essential part of pre-service and in-service teacher training.

Carr-Chellman (2021) makes the point that the emergency pivot to online learning during the pandemic was largely unplanned and was therefore unrepresentative of 'true' online education. Therefore, there is a risk that contemporary studies of online education during the pandemic may undermine decades of previous research showing its effectiveness when it is carefully planned and intentional. My work is positioned prior to and during the pandemic; music teachers' changing attitudes to videoconferencing and low-latency technologies are documented in this thesis.

### 2.4.2 Emerging technologies in music education

Wise et al. (2011) discuss a variety of different understandings of the term 'music technology', ranging from Byrne and MacDonald (2002) who include any hardware or software used in the production of music, such as electronic

keyboards, sequencers, and music editing software; to Webster's suggested definition as 'inventions that help humans produce, enhance and better the area of sound organised to express feeling' (Webster, 2002, p.416).

The use of music technology is briefly discussed in A Common Approach 2002:

> Music technology cannot replace teachers or traditional instruments, nor should it be used as the only source for musical learning. Nevertheless, used appropriately and sensibly, ICT can integrate with and support other ways of learning and open up new horizons. ICT can also help to motivate pupils of all abilities (Federation of Music Services and National Association of Music Educators, 2002, p.28).

Bowman (2014) notes that digital tools are now so ubiquitous that students expect to use them on a daily basis in both their personal and educational lives, and that as teachers become more comfortable and familiar with these tools, they are increasingly likely to use them as part of their everyday teaching practice both in face-to-face and online teaching environments. The COVID-19 pandemic has shown that digital tools have become essential, as students without access to a device or a reliable internet connection during school and Higher Education closures were not able to participate adequately in learning (OECD, 2020).

### 2.4.3 Technologies to support music practice

Practice is an essential element of learning to play a musical instrument, and as Harris (2012, p.71) writes, 'for most, though not all [students], progress will be unlikely without it'. In my experience of teaching, young students who initially appear musically talented can often be overtaken in terms of progress by seemingly less-able students who have developed a robust self-regulated practice routine.

For school age students, practice is mostly done in the home, and a supportive home environment is important in providing a space away from

other distractions, and also setting times for practice (Creech, 2010). Parents and families can support a child's musical learning in other practical ways, such as providing appropriate resources (e.g. sheet music, reeds, strings, etc.); transport to and from lessons, rehearsals and concerts; and appropriate emotional support (Hallam, 1998, p.75).

The *Making Music* document (ABRSM, 2014, p.43) reports a survey of instrumental teachers stating that unsupportive or uninterested parents are a particular issue for students of primary school age. Parental expectations of children, both positive and negative, can become self-fulfilling prophecies (Davidson and Borthwick, 2002). Creech and Hallam (2009) report evidence of a positive effect of parents having appropriate ambition for their child, along with effective communication with the teacher. Creech (2010) also notes the positive outcomes that can be achieved by parents that provide a structured environment for musical practice and take an active interest in their child's development. However, Harris gives an amusing caricature of parents with questionable ambitions for their child wishing to learn an instrument: 'and we'll get so much pleasure out of it as we show off your exam results and delight in your performances in school concerts and compare you to our friends whose children don't learn musical instruments' (Harris, 2012, p.33).

Good communications between teacher and student, teacher and parent, and student and parent are therefore necessary to ensure that the parent is supportive and yet realistic about their child's potential. However, while positive parental involvement is important, Harris (2012) notes that as a student progresses, they must take more personal responsibility for their learning. Self-regulated practice therefore becomes an essential component of instrumental music learning (Upitis et al., 2013).

Communications between teacher and student, teacher and parent, and teacher and school music department can be greatly enhanced using timely email communications and the use of digital tools such as a Digital Learning Portfolio (DLP). Frazes Hill (2008) discusses how the DLP can be used as a resource for storing PDFs of sheet music, backing tracks, demonstration

videos, as well as student self-recordings, and they can in turn be used as tools for monitoring progress, assessment, and also for self-reflection.

Upitis et al. (2013) and Brook and Upitis (2015) describe the development of the iSCORE DLP and how in addition to storing resources, it allows for students to plan and reflect on their learning, with a facility to receive teacher feedback between weekly lessons. They report on students' (n=74) enjoyment of the social aspects of the tool, and that students felt more empowered in taking ownership of their own learning. They also note that 'technology can reduce isolation for music students and teachers' (Upitis et al., 2013). However, digital tools may not suit the learning styles and abilities of all students, particularly those lacking in technological competence or not wanting to have their performing critiqued by others. I have found that the MS Teams platform has served this function well since the first COVID-19 lockdown in March 2020 and I continued to use this tool, as reported in Study 7 (Chapter 5, Section 5.4).

### 2.4.4 The role of technology in informal learning

Informal learning is defined as a lifelong process in which a person acquires knowledge and skills from daily experiences, and is therefore unstructured and unconstrained; conversely, formal learning is defined as following systematised established forms, customs, or rules (Jenkins, 2011).

Key differences between informal and formal music learning practices are noted by Green (2002), with informal practices including:

- choice of repertoire the learner has selected by themselves;
- copying audio recordings by ear, without notation;
- self- and peer-directed learning, typically without adult guidance;
- holistically-acquired skills, rather than those resulting from a pre-arranged curriculum;
- highly-integrated activities of listening, playing, composing and improvising (ibid.).

Informal learning can also take place online via instructional videos hosted on sites such as YouTube (Kruse and Veblen, 2012; Waldron, 2012a). A report by ABRSM (2014) suggests that 21% of children who play musical instruments learn through informal routes such as peer-to-peer networks and accessing digital tools, and since the COVID-19 lockdown, the percentage is likely to be much higher.

### 2.4.5 Massively open online courses (MOOCs)

The term MOOC describes a course that has a high number of participants (massive), is free of cost and without entry requirements (open), and is held entirely online (Future Learn, 2020). The number of participants in MOOCs worldwide has steadily risen, with a large expansion since March 2020. By November 2020, it was estimated that 180,000,000 students had enrolled on 16,300 courses offered by 950 universities (Shah, 2020). Student enrolments on MOOCs may be high, though as Garcia (2020, p.191) reports, of the 160,000 students enrolled on an early MOOC on Artificial Intelligence offered by Stanford University in 2011, 'many' (number not stated in the literature) did not complete the course.

Steels (2015) writes that MOOCs are a logical result of the mixing of distance education with the Internet and social media, and that MOOCs are a valuable addition to both teachers and students. MOOCs appear to have many benefits over traditional courses, the most obvious being availability to anyone with internet access, at a time and place of their choosing. Many MOOCs are designed to encourage student interaction through forums and discussion boards stimulating 'open ended learning environments that support constructivist learning' (Steels, 2015, p.vii). However, peer feedback can be variable in quality, and learners may be disheartened or discouraged by peer comments.

Steels (2015) describes two different paradigms for learning and teaching that have been used in creating MOOCs. The first is the 'constructivist' or natural learning approach, in which learners actively and autonomously explore and

make sense of the world through constructing models, which they then use to solve problems. The second approach is ‘instructional’, in which knowledge is viewed as an association in response to a situation, with pedagogies based on strict lesson plans with continuous assessment.

Online learning is increasingly being combined with traditional classroom methods to create a new hybrid methodology described as ‘blended learning’ (Garcia, 2020, p.192). Using the ‘flipped classroom’ model (Esperanza et al., 2016), teachers can post videos and content for students to watch in advance, allowing more time in the face-to-face lesson to work on applying concepts, solving problems and answering student queries.

### 2.4.6 Instrumental teaching via videoconferencing

There is a comparatively limited amount of literature concerned with instrumental music teaching via videoconferencing, and most of the available literature reports on small-scale interventions and case studies. Hence, it is difficult to make generalisations from these studies, and the research presented in this thesis partly addresses this gap. Those studies which do exist suggest that not being able to perform together due to issues of latency and software was an issue for teachers (Dammers, 2009; King et al., 2019; Koutsoupidou, 2014; Kruse et al., 2013; Shoemaker and van Stam, 2010).

The use of videoconferencing has been shown to successfully facilitate instrumental music lessons between teachers and students in remote locations (King et al., 2019; Shoemaker and van Stam, 2010). The reported advantages include increased access for teachers and students and a reduction in travel, thus saving time, expense, and environmental damage. However, important elements such as playing together are missing from lessons delivered via conventional videoconferencing platforms due to issues of latency (Redman, 2020).

Videoconferencing was originally developed to facilitate video and audio conference calls between two or more remote parties and was therefore

optimised for speech. As such, it was not intended to be used to facilitate synchronous musical interactions (Drioli et al., 2013). Yet, despite its technical deficiencies, even before the pandemic videoconferencing was gaining acceptance as a method of delivering instrumental lessons as well as auditions.

In an early case study, Dammers (2009) reports on trumpet lessons via videoconferencing between one teacher and one eight-grade student (aged 13-14) over the course of nine weeks. Though limited in scope, the study demonstrated that the teacher was able to provide helpful feedback, and the student made progress. Both the teacher and student had initial reservations about using videoconferencing, but these proved to be unfounded. The teacher had to adapt their teaching practice to suit the format, which included increased planning and making the lessons more structured. There was a change in the social dynamic, but the most obvious drawback was the latency in the system making it impossible to play duets together. The teacher developed some recommendations for future practice and suggested that in the future, increased processor speeds, more robust networks, increased sound and visual quality and reduction of latency would improve the experience. However, at the time of writing, the format was only recommended as a supplement to face-to-face lessons.

Shoemaker and van Stam (2010) report on a case study in rural Zambia using digital pianos. This study was also limited in scope, using just one teacher and two students. The teacher was creative in their approach and recognised that the synchronous environment allowed the teaching to be customised to the student and tailored to the student's own learning. Technological problems with synchronous lessons led the teacher to adapt their teaching to add asynchronous learning. Both methods were shown to have advantages and disadvantages, but the combination of the two methods proved to be effective with both students. Latency precluded ensemble playing, and as discussed previously in this review, this is one of the most important aspects of music learning. Online collaborative learning (OCL) was achieved by students posting video recordings of their performances to the video-sharing site Vimeo

for peer and teacher review, and this added an extra dimension that was enjoyed by the students. The teacher acknowledged that barriers of resources and time may be prohibitive to some learners using OCL, and that an adult possessing some basic computer knowledge should be on hand to provide technical assistance and support where necessary.

Another case study is reported by Kruse et al. (2013) in which piano lessons were conducted with one student and one teacher via Skype over one semester in a Higher Education setting. The study explored the benefits and challenges of online learning in the music academy. Data were collected through observations, interviews, e-journals, and video recordings. The teacher and the student reported enjoying the novelty of using videoconferencing, but both were also initially apprehensive at the loss of the familiar face-to-face lesson setting. Technological problems with the Skype platform were reported, along with a literal and figurative disconnect (Kruse et al., 2013). Other reported problems included the financial considerations for the student in purchasing the appropriate resources, together with skill and knowledge acquisition for both parties in relation to using the equipment. It was also noted that the level of communication and understanding can impact the quality of the student-teacher relationships in both face-to-face and online lessons. Kruse cautions against making general conclusions from the findings of this case study as any discussion of specific technology risks quickly becoming outdated.

A more substantial study was carried out in North Yorkshire involving six teachers, four schools, and over 40 students aged 7–11. The study was conducted over 14 weeks, using clarinet, guitar and violin (Prior et al., 2015). The aim of the project was to repurpose existing technology to provide peripatetic music lessons in remote rural communities. The study investigated the technical challenges of these modes of delivery, pedagogical aspects of the delivery, and the similarities and differences between digitally-delivered and face-to-face instrumental lessons. The use of videoconferencing allowed students to participate in music lessons who would have otherwise not had the opportunity due to their remote location.

The study in North Yorkshire was followed by deployment of the technology in four other rural areas in England: Cornwall, Cumbria, Durham/Darlington and East Riding of Yorkshire, with over 110 school pupils participating between 2014 and 2017 (King et al., 2019). This was followed by a national launch in 2017 with a further seven music hubs in England and Wales. Technological problems were identified, with satisfaction rates of sound quality (7/10), video quality (4/10) and internet connection (5/10) reported. Teacher concerns about assembling instruments and tuning were overcome by teaching standard protocols, enlisting adult help and tuning apps, and making pre-recorded videos. The trial experimented with the use of multiple cameras, and the findings showed that a two-camera setup worked well, with one camera for a main view of the teacher with a further camera for close-up work for showing fine detail and technique.

One of the challenges for teachers was the inherent latency in using Skype, though some teachers partly overcame this problem by asking children to count for one another in their group lessons. Teachers adapted their behaviour by being more verbally explicit, while using less modelling behaviour. Teaching beginner bow hold for string students was reported as being particularly difficult. All students reportedly made progress and while most reported enjoyed the lessons, face-to-face teaching was seen as preferable to videoconferencing (King et al., 2019).

Koutsoupidou (2014) discusses the benefits and challenges of online distance learning in music, and reports on a survey of the attitudes of university teachers. Teachers were reported as being enthusiastic about asynchronous lessons for theory subjects, but less so for instrumental lessons due to the technical problems of videoconferencing. Koutsoupidou argues the need for higher internet speeds for synchronous videoconferencing lessons, and better constructed virtual environments to diminish the ‘socio-psychological’ gaps caused by online learning (Koutsoupidou, 2014).

Levinsen et. al (2013) report on studies at the Royal Danish Academy of Music (RDAM) involving staff who are experienced in teaching, yet novices in

the use of videoconferencing. They discuss the concept of ‘the third teaching room’, which they define as: ‘The mutually shared feeling of being and doing together in an individual and mentally constructed merge of the VC-mediation, the near and the remote locations’ (Levinsen et al., 2013). They note that ‘Being in the third teaching-room is a matter of being able to see and hear what is needed when it is needed and being able to act and interact in appropriate ways’ (ibid). Technicians became important facilitators of the third teaching room as they helped to mitigate both technical and collaborative problems via a parallel communication system without disturbing the participants.

The case studies at RDAM report on lessons in cello, piano and singing, and noted differences between the three instruments in the videoconferencing setting. The findings showed that cello was suited to videoconferencing due to the participants being placed towards each other in both face-to-face and videoconferencing sessions, and a medium camera shot allowed views of both whole body and more detailed hand positions. The singing lessons required participants to be able to see full body and close-up facial expressions, which can be a challenging experience for both teacher and student in the videoconferencing lesson. The tonal quality of the singer’s sound, together with breath control and body movement, were more difficult to discern in the videoconferencing lesson. The piano lesson also differed as teacher and student are often seated side by side in the face-to-face lesson, thus direct eye contact is not a normal part of the face-to-face lesson. However, the student experienced unease if the teacher failed to establish eye contact when giving critical feedback during the videoconferencing lesson. Non-verbalised communication that would normally be found in the face-to-face lesson had to be made explicit through gesture and metaphor-loaded dialogue. As a consequence, the participants reported experiencing hyper-focus during the videoconferencing lesson, followed by fatigue afterwards (Levinsen et al., 2013).

Iorwerth and Knox (2019) report that whereas there is a body of research concerned with the effects of latency in Networked Music Performance

(NMP), the qualitative experiences of musicians in NMP situations have largely been overlooked by researchers. Audio and visual communication is inevitably disrupted, affecting not just musical timing, expression and interpretation, but also social interaction, resulting in feelings of disconnection. The visual element in NMP environments is perceived as less important than the audio element, particularly when there are audio cues, and tempos remain fairly constant. However, visual cues became more important when the intentions of co-performers were unclear or difficult to predict, and peripheral vision is used in a variety of musical situations to detect body language and musical cues. Thus, the use of monitors in NMP settings affects the ability of musicians to respond to musical cues. Additionally, the physical separation affected social interaction, which in turn affected confidence between participants.

Duffy and Healey (2017) report on trials that revealed a fundamental change in how teachers and students shared their space during the videoconferencing lesson when compared to the co-present lesson, with communication problems during the lesson affecting the student more than the teacher. They propose the development of an interactive digital score that allows digital annotations from both teacher and students through the use of a stylus. These digital markings could then be selectively hidden from view to revert to a clean score, or for students to view just their own and/or their teacher's markings. They also propose the development of eye tracking technology which would allow access to the focus of their co-participant's gaze on the shared score, to ensure they are looking at precisely the same place in the music. They also imagine a further layer on the score allowing gestures and fingerprints from the teacher indicating where they want the student to focus.

However, this seems to be rather overcomplicating a simple matter. In the first instance, scores are not an essential part of all music lessons. For example, traditional or folk music is an aural tradition and often taught without sheet music. Jazz musicians may refer to a score, but by its very nature, the improvisation is not notated. Furthermore, a teacher can quickly annotate a

paper score and scan or photograph the music, or simply annotate a PDF and email to the student during the lesson. In my more recent experience, I found that sharing a pre-prepared PowerPoint presentation with students helped to achieve the same goal of having the teacher and student focus on the same place in the score.

The literature on videoconferencing from this survey showed two different approaches to improve the experience of remote lessons: multiple-camera setups, and interactive score notation. However, these approaches do not address what I consider to be the key problem associated with remote lessons delivered via videoconferencing: the latency and switching that prevents synchronous performance. As a result, I have chosen to focus my research on attempting to achieve synchronous performance via low-latency technologies, which will be discussed in the next section.

## 2.5 Low-latency technologies

### 2.5.1 Introduction

When I began my research in 2014, there was very little published literature on low-latency technologies. The available literature shows that low-latency systems such as LoLa and UltraGrid offers the opportunity for musicians to rehearse and perform together (Drioli et al., 2013) but, as yet, there is little published research on how effective these tools are when used in educational settings. The available literature suggests a need for more in-depth testing (Riley et al., 2014; Davies, 2015; Iorwerth and Knox, 2019) and this is a gap that my research fills.

### 2.5.2 LoLa

In response to the demand from musicians for more effective audiovisual streaming systems, LoLa (low-latency audiovisual streaming) was conceived at the Conservatorio di Musica Giuseppe Tartini of Trieste in 2005 and developed between 2008 and 2010 with the collaboration of Gruppo per l'Armonizzazione delle Reti della Ricerca (GARR), the consortium that runs

the ultra-broadband network dedicated to the Italian research and education community (Drioli et al., 2013). LoLa is a software package that runs over a specialised network on an expressly specified Windows PC, with dedicated graphics and sound cards. It was designed to allow remote parties to perform and interact together in real-time with high-quality audio, something not currently possible with standard videoconferencing platforms.

The first public demonstration of LoLa took place in November 2010 as a piano duo performance, with one performer in the Music Conservatory in Trieste, and the other in the institute for Research and Coordination in Acoustics/Music (IRCAM) in Paris, a distance of approximately 1,300 kilometres apart (Drioli et al., 2013). LoLa can also be successfully used in other performance contexts such as dance and theatre, as well as wider applications such as medical training (Ubik et al., 2016).

The success of LoLa depends on a variety of factors, such as a fast high-capacity network such as GARR in Italy or the Joint Academic Network (Janet) in the UK, and the availability within those institutions of support from network engineers, sound engineers and technical staff (Davies, 2015). This may not be a problem for well-established and sizeable academic institutions that are likely already to be connected to such a network, but it represents a major infrastructural challenge for more isolated communities and individuals.

Riley et al. (2014) report on a study that compared three different platforms (LoLa, Polycom and Skype), with LoLa receiving the highest user satisfaction rating. The study supports the notion that latency remains an obstacle in distance learning, and that reducing latency is crucial for interactive music instruction and user satisfaction. They also reported that high-quality audio was necessary for aural accuracy, and that performers experienced difficulty adjusting to digital sounds.

Additional issues were noted in the studies including difficulties with adjusting students physically, difficulties with maintaining eye contact, and difficulties with modelling the physical characteristics of playing. They also noted that

consecutive lessons were more successful than individual lessons so as to allow for a period of adjustment to working in the online environment. Lessons required more preparation on the part of the teacher, including emailing PDFs of music. They also discussed the possibility of having multi-camera and multi-microphone setups. Despite the problems with delay in all platforms, they take the view that synchronous online learning in music has been successful. They also note that many more tests are needed to determine the effectiveness of LoLa in education; my research addresses this issue.

Davies (2015) reports on seven case studies that took the form of rehearsals, performances, coaching sessions, and master classes. Davies reports that factors affecting musicians' ability to tolerate the latency in the LoLa sessions included their level of experience in dealing with latency in conventional music spaces together with the instrument that they play, and the quality of the sound via the LoLa system. Challenges came from listening to different sound sources: their own sound, the sound of musicians co-located in the same physical space, and the digitally-mediated sound of their remote partners. The use of visual cues differed between settings: jazz musicians tended to look towards their remote partners for gestures and cues, whereas classical and also less experienced musicians tended to focus more on the score. Screen size and positioning, together with camera positioning, were important factors in achieving comfort for remote participants.

Participants reported initially being uncomfortable with the LoLa technology; however, the more they used LoLa the more comfortable they became with the system. As reported in other studies (Duffy and Healey, 2017; Iorwerth and Knox, 2019; Levinsen et al., 2013), communication styles changed for both tutors and students, with tutors often using exaggerated gestures. Another challenge is overcoming attitudes towards using the technology and, as will be reported in later chapters, this can prove to be a major barrier in adopting any new technology. However, in light of COVID-19, attitudes to using online technologies have recently changed.

Davies (2015) reports the need for a critical mass of institutions to be actively using LoLa to allow collaborations between institutions. LoLa requires a high-capacity network to operate effectively. In addition, it requires a supportive network engineer at an institution, together with sound engineers to optimise the audio quality. At the moment, this means that LoLa is only accessible by institutions with a high-capacity network, which currently precludes most schools in Scotland. Thus, no research has taken place to date using LoLa in school settings.

### 2.5.3 JackTrip

JackTrip is a low-latency, high-quality audio-only free and open source software program developed for use over the Internet (Cáceres and Chafe, 2010). It was developed by Chris Chafe and Juan Pablo Cáceres at Stanford University beginning in 2000 (Hadhazy, 2020), featuring bi-directional, multi-channel, multi-site uncompressed audio (Ferguson et al., 2020). It can be installed on a standard PC or Mac, or an inexpensive standalone device such as a Raspberry Pi. There is a relatively small amount of published literature on JackTrip, with most relating to the Networked Music Performance (NMP) environment (Cáceres et al., 2008; Mizuno, 2012) or technical literature.

Meier et al. (2014) report on the JamBerry project, the first ‘standalone device for networked music performance based on the Raspberry Pi’ (Chafe and Oshiro, 2019, p.1). The JamBerry project used custom software written for a ‘system-on-chip’ combined with an audio interface and a built-in touch-screen interface (ibid.). This meant that external peripherals such as a monitor were not required, other than an input device (instrument or microphone via the audio interface) and output device (headphones or amplifier) (Meier et al., 2014).

Using a system similar to the JamBerry, Chafe and Oshiro (2019) demonstrated the use of JackTrip software on the Raspberry Pi. They describe the functioning of JackTrip on a Raspberry Pi as being identical to running it on a PC or macOS, but instead using the relatively low-cost

hardware of the Raspberry Pi, together with off-the-shelf USB sound cards. The Raspberry Pi 3 Model B+ has input and output ports, as well as built-in ethernet, HDMI and USB ports for connection to wired ethernet, display, mouse, keyboard, and soundcard (ibid.).

As reported in Chapter 8, Section 8.3, JackTrip has recently been developed to run on standard networks, 'to make the performance of music over the Internet feasible and accessible to everyone' (JackTrip Foundation, 2021a). Due to this recent development, there is limited literature available on the use of JackTrip for educational uses, and this thesis contributes to the field.

## 2.6 Networked Music Performance

Live music collaboration via technology is not a new phenomenon; Dessen (2020) reports on US political activist Paul Robeson being prevented from travel in 1957 by McCarthy era regulations, but still participating in a choral festival in Wales via transatlantic telephone lines run by a mineworkers union. Since then, there have been many attempts at multi-site music making, including computer-aided electro-acoustic music from the 1970s (Rottondi et al., 2016). These have since expanded with the introduction of the Internet in 1993, to become 'telematics music' or as more commonly referred to now, Networked Music Performance (NMP).

NMP is described by Rottondi et al. (2016, p.8823) as 'remote music performance systems supporting real-time synchronous musical interactions among geographically-displaced musicians'. As reported by participants later in this thesis, elements of musical interactions from the face-to-face environment are missing in remote musical interactions, including the natural audio reverberation from acoustic instruments (Study 13, Chapter 6, Section 6.6.4), sensing the breathing of other players (Study 14, Chapter 7, Section 7.2.4), and the visual element provided by peripheral vision of other players including gestures (Study 2, Chapter 4, Section 4.3.6 and Chapter 6, Section 6.5.2). However, the most problematic element, and one that also occurs in

face-to-face environments where distance between performers is involved, is latency.

Rottondi et al. (2016) describe three strategies employed by NMP practitioners to respond to latency: realistic interaction in low-latency environments, where musicians interact with no awareness of delay as in most face-to-face environments; leader and follower, as observed in the recording sessions via LoLa (Chapter 6, Section 6.5) where a leader sets the tempo and effectively ignores the other; and delayed feedback, where self-delay is artificially added to a musician's own audio feedback, equal to the total roundtrip delay, so as to sound in synchronisation with the other party. A fourth strategy described by Sarah Weaver in Section 8.6 is of abandoning 'steady-beat music' in favour of music that employs other strategies, such as call and response.

## 2.7 The effect of the COVID-19 pandemic on education

The COVID-19 pandemic has significantly affected the health, economic and emotional wellbeing of populations around the world. The lockdowns introduced to try and suppress the transmission of the virus brought a halt to sports and cultural events as well as the closure of schools, universities and most workplaces, and thus an almost complete halt to normal social life (Biasutti et al., 2021). This disruption resulted in feelings of insecurity, confusion and emotional isolation in populations (Antonini Philippe et al., 2021).

The pandemic also caused a rapid shift in how education was delivered from March 2020 onwards, and research articles are now beginning to emerge that cover many of the various aspects of this change. Kim and Asbury (2020) report on a survey of teachers in English schools during the first six weeks of the lockdown. The findings showed that after some initial uncertainty, the teachers were able to settle into online teaching. There were concerns about how best to support the most vulnerable children, and there was also a desire for greater clarity from government to enable forward planning. There are

relatively few articles specifically concerned with music teaching during this time, but three are discussed in this section.

Biasutti et al. (2021) discuss a study into how conservatoire teachers in Europe and the USA adapted existing teaching practices and devised new strategies to cope with the sudden change to online learning and teaching. Teachers reported finding the change to online learning time consuming and stressful due to unfamiliarity with new technologies, the need to plan new activities, and preparing new materials. Teachers also reported subsequently becoming more organised in the management of these different activities, and finding various platforms for sharing material, communicating with students and keeping records of work to be useful. Participants in the study also became adept at using asynchronous video clips for modelling and teaching. Teachers on the whole were inadequately prepared for the rapid change, and there was a call for greater institutional support and professional development opportunities.

Nusseck and Spahn (2021) report on the experience of 18 music students and their musical practice during lockdown. The findings show that students' behaviour changed during this time; they became more autonomous from their teachers and developed a more individual and self-regulated style of practice. The study suggests a rethinking of instrumental music teaching, from teacher-oriented to learner-oriented, with greater emphasis on self-regulated learning.

Hash (2021) discusses the experience of school band directors in the US during the COVID-19 lockdown. The findings showed that the move to remote learning caused problems for schools with higher levels of deprivation and also those in rural locations. However, remote learning also created opportunities for teachers. These included focussing on each student's individual musicianship; exploring a wider range of technologies; having a greater emphasis on supporting studies such as music theory and music history; and encouraging greater student creativity through composition.

## 2.8 Discussion

In this section, I discuss my critical analysis of the gaps that exist in the literature in the various domains, which provides the rationale for my research questions that are listed at the end of this chapter.

Videoconferencing was increasingly being deployed as a means of delivering instrumental music lessons in schools and Higher Education before the COVID-19 pandemic (King et al., 2019). As technology and infrastructure improves, videoconferencing and low-latency technologies are likely to be accepted as a more permanent method of delivering lessons, rather than a temporary solution during COVID-19. This research contributes to the understanding of the potentials and limitations of these technologies.

In assessing the suitability of these technologies for instrumental music teaching, it is useful to consider whether they provide the necessary functionality to address the six key areas identified in *A Common Approach 2002* (Federation of Music Services and National Association of Music Educators, 2002): developing instrumental and vocal technique; listening to and internalising music; creating, developing, and interpreting musical ideas through improvisation and composition; playing music by ear, from memory, and by sight; performing with others; and interpreting and communicating the character of the music, including pupil self-evaluations of their own performances. Five of these six areas are possible using videoconferencing and asynchronous online methods, but the literature shows that not being able to perform together due to issues of latency was an issue for teachers, and the case studies reported dissatisfaction with network stability and audio and video quality using platforms such as Skype (Dammers, 2009; King et al., 2019; Koutsoupidou, 2014; Kruse et al., 2013; Shoemaker and van Stam, 2010).

There is much evidence on the benefits of learning to perform with others, and an essential part of this is learning to perform with the teacher (Kokotsaki and Hallam, 2011; Welch et al., 2014). ‘Teaching through playing’ in musical

ensembles with the guidance of an expert musician (Zhukov and Sætre, 2021) has been a method of transmission of musical skills and knowledge in genres such as folk and jazz music long before these genres became part of the modern conservatoire culture, but it is now increasingly being used within conservatoires in all genres. Low-latency technologies expand this possibility by facilitating its use between conservatoires.

The available literature shows that low-latency systems such as LoLa allow musicians to rehearse and perform together (Riley et al., 2014; Davies, 2015; Drioli et al., 2013; Iorwerth and Knox, 2019; Redman, 2020; Ubik et al., 2016) but, as yet, there is little published research on how effective these tools are when used in educational settings. The literature suggests a need for more in-depth testing in education settings, and this is a gap that my research fills.

The recent literature on one-to-one teaching in conservatoires suggests that there should be a move from away from an over-reliance on just one teacher, and that students should receive a broader range of input from other sources, including other teachers (Burwell et al. 2019). This would facilitate a greater awareness of different styles and genres of music, as well as different instrumental techniques. There would also be a reduction in the possibility of harm to students from one over-dominant teacher. Other transformative aspects of instrumental teaching with technology include the use of online student portfolios, as well as using asynchronous resources such as instructional videos (Kruse and Veblen, 2012; Upitis et al., 2013).

Videoconferencing and low-latency technologies allow for the expansion of traditional instrumental music one-to-one teaching beyond the four walls of a conservatoire, school, or private studio. In addition to benefitting students, this also allows for teachers to observe how other teachers teach, and also to share and exchange knowledge of different teaching styles and instrumental techniques. This is particularly useful in an instrumental discipline such as percussion, where there are a wide variety of different instruments and techniques to master.

Koutsoupidou (2014) discusses the ‘socio-psychological gaps’ between participants that occurs in online music education, and while research into low-latency technologies shows that it allows musicians to rehearse and perform together, the question as to how successful this would be as a medium for online music education is unanswered. Another question is how the experience changes between the co-present and the remote music lesson, and how it affects musicians in different instrumental disciplines, at different ages and stages of development, and in the different settings of HMEIs, school, and domestic use. My research explores this qualitative aspect of learning and teaching using videoconferencing and low-latency technologies and contributes to knowledge in this field.

Common themes from literature on the pandemic show that while many teachers were initially unprepared for the transition to online teaching, they were able to quickly adapt, and also find some added benefits to using online methods (Hash, 2021; Nusseck and Spahn, 2021). There was a call for more professional development in online teaching methods (Biasutti et al., 2021), and also a concern about vulnerable students being further disadvantaged by a digital divide (Kim and Asbury, 2020).

Another theme to emerge from the literature is that the pandemic has provided an opportunity to rethink instrumental music teaching and move towards more self-directed and self-regulated learning (Nusseck and Spahn, 2021; Gaunt et al. 2021). The literature also suggests that instrumental music teaching practice is its own domain and ‘should be approached and understood on their own terms’ (Burwell, 2018, p.21) and while it does not easily fit within existing learning theories, there is an opportunity for exploring new learning theories, especially in light of the new reality of COVID-19. It is beyond the scope of this study to attempt to answer this deeper philosophical question, but in the concluding chapter there are suggestions for a reimagining of instrumental teaching.

Carr-Chellman (2021) suggests that there is a risk that contemporary studies of online learning during the pandemic may undermine previous research

showing its effectiveness when carefully planned and intentional. This also applies to the largely unplanned pivot to instrumental teaching using videoconferencing, and there is a danger that videoconferencing and online teaching becomes conflated with poor-quality or 'less-than face-to-face' teaching, and my research also aims to provide evidence of quality teaching using these methods, when properly planned and delivered.

As discussed by Koehler and Mishra (2009), it is essential for teachers to understand what changes when technologies are deployed in different ways. If teachers simply try and reproduce what they already do in the face-to-face environment in the online environment, they are potentially missing some of the additional functionality provided by online learning. Ruthmann and Herbert (2012) suggest that researchers should reflect on the question of which elements of music teaching are best suited to the face-to-face and the online environment, and my second research question directly address this.

As reported later in the thesis (Chapter 8, Section 8.3), JackTrip has very recently been developed to run on standard networks, 'to make the performance of music over the Internet feasible and accessible to everyone' (JackTrip Foundation, 2021a). Due to this recent development, there is a paucity of published literature on the use of JackTrip for educational uses, and this research contributes to the field.

As Clements (2018) argues, determining the effectiveness of technology will always present challenges, and it is important to critically explore and reflect on whether digital tools that make life 'easier', also make life 'better' for us, both as individuals and societies. It is hoped that the research presented in this thesis contributes to a deeper understanding of the potential impact of low-latency technologies on instrumental music teaching.

In summary, the gaps identified in the literature are as follows: a need for larger-scale testing of low-latency technologies in instrumental music teaching, a greater understanding of the quality of the experience in face-to-face and remote teaching environments, and an understanding of how the

learning and teaching changes in these environments. This led to three overall research questions:

- Research question 1: What changes in the quality of the interactions and the learning and teaching experience in lessons between face-to-face, standard videoconferencing, and low-latency environments?
- Research question 2: Are some elements of music instruction more or less effective in these different environments?
- Research question 3: What are the barriers to using these technologies in educational settings, and how can these be overcome?

The methods for answering these questions are addressed in the next chapter, along with considerations of ethics, validity, and bias.

# Chapter 3: Methods

## 3.1 Introduction

The previous chapter reviewed literature related to learning theories, instrumental music teaching, online learning and teaching, technology, and recent literature relating to the effect of the pandemic on education. From this review, I have identified a need for larger-scale testing of low-latency technologies in instrumental music teaching. This chapter develops the theoretical framework for my research and is organised in six sections. The introduction gives an overview of the research studies. I then discuss the research paradigm; the data collection methods used; the methods of coding and analysis; considerations of validity, biases, and ethics; and conclude with a discussion section and a table summarising the studies (Table 1).

For this project, I deployed a mixed methods concurrent nested design; data were collected from different parallel studies, with a quantitative study nested within qualitative studies (Aultman, 2020). Autoethnography was employed as it allowed me to immerse myself in the use of the technologies, to reflect on my personal experience, and to 'gain profound understanding of self and others' (Chang, 2016, p.13) with a wide variety of participants from different backgrounds. Research methods were chosen to ensure a useful dialogue between myself as the researcher and the research participants.

Primary research was undertaken in order to collect and interpret original data and elicit information from a wide range of participants, including experts, so as not to be unduly influenced by other researchers' interpretations and conclusions (Ruszkiewicz et al., 2006). Secondary research drew on a range of sources including: scholarly, professional and technical literature; conference attendance; and monitoring music teacher comments on social media platforms following the COVID-19 lockdown of March 2020. The research was conducted in two phases and was primarily qualitative. The first phase investigated videoconferencing, with the second phase investigating low-latency technologies.

The first phase began with a pilot study (Study 1) using semi-structured interviews to establish a baseline of attitudes and views of instrumental music teachers on the use of videoconferencing. Study 2 built on this to explore videoconferencing in greater depth with teachers and students with particular experiences or expertise. Study 3 was quantitative and used observation to establish how frequently teachers played together with students in face-to-face lessons, an element not currently possible in videoconferencing lessons. This study was used to validate the next phase of research into the use of low-latency technologies that facilitate playing together in lessons. Supplementary data was gathered in Study 4 by monitoring music teacher comments on social media platforms to the emergency pivot to teaching online immediately following the COVID-19 lockdown.

I undertook autoethnographic studies (Chapter 5), putting myself in the role of both teacher (Studies 5–7) and learner (Study 8), in order to understand the complexities of learning and teaching using videoconferencing. Studies 5 & 6 were followed by semi-structured interviews with trial participants. In Study 8, I also participated in informal learning through Massively Open Online Courses (MOOCs) to better understand the use of asynchronous resources to support learning and teaching, and I also observed YouTube videos, webinars, and individual teacher-generated online content.

The second phase of the research (Chapters 6–8) investigated the use of low-latency technologies through five teaching trials, followed by participant interviews. Study 9 was a test of concept using LoLa technology to establish the minimum bandwidth required for using LoLa in compression mode. Establishing that LoLa could be used with a modest bandwidth allowed two further trials to proceed between the Royal Conservatoire of Scotland (RCS) and Edinburgh Napier University (Studies 10 & 11). In Study 12, I observed the use of LoLa in recording sessions between Edinburgh Napier University and the Royal College of Music in London, and Edinburgh Napier University and Berklee College of Music in Boston, USA. Analysis of a larger-scale trial of LoLa in three European conservatoires provided further in-depth experiences from a wider range of trial participants (Study 14). JackTrip

audio-only technology was also trialled at Edinburgh Napier University (Study 15), and additional interviews were conducted with teachers and administrators experienced with using low-latency technologies (Studies 13, 16 & 17).

## 3.2 Research paradigm: ontology, epistemology and methodology

My approach is aligned to an 'interpretivist' paradigm (Coe, 2017), as I do not believe there is a single, objective experience that will hold true for all participants. For example, the experience of an adult cello student in a conservatoire using the high-quality LoLa system will likely be very different to that of a nine-year old beginner percussion student using Skype in a rural area using a Wi-Fi connection. I am looking through the lens of a 'relativist' ontology (Waring, 2017) as my view is that each participant will have interacted with their learning environment in different ways, and each will have constructed their own subjective reality through their own lived experience. While not seeking a single universal truth that can be applied to all teaching situations using these technologies, I am also allowing for general themes to emerge from the research.

I am adopting a 'subjectivist' epistemology (ibid.), as I recognise that it is difficult to separate myself in the role of researcher from what I already know through my own general experiences as a musician, a teacher, a student, and also specifically through my autoethnographic studies. Similarly, what each participant knows, and how they understand the world, is a central part of how they interact with the research process.

The participants have shared their experiences, opinions, and personal narratives and dialogues (Marshall and Rossman, 1999), and the research findings have been created through dialogue as the studies have progressed (Coe, 2017). Through this dialectical process, conflicting opinions have been negotiated, and a more sophisticated understanding of the use of videoconferencing and low-latency technologies has been created.

## 3.3 Data collection methods

### 3.3.1 Semi-structured interviews

According to Drever (1995, p.8), semi-structured interviewing 'is a very flexible technique, suitable for gathering information and exploring people's thinking and motivations; [and] yields rich information and guarantees good coverage'. This technique was considered the most suitable for gathering data as it allowed participants to discuss issues in some depth, while keeping the topics structured and focussed. An alternative approach using quantitative surveys was considered; this would have allowed me to potentially reach a wider group of participants, but I chose interviewing as the most suitable method so as to be able to follow up discussion points with individuals and gain a more in-depth understanding of issues.

Two rounds of semi-structured interviews were conducted at the start of the project (Studies 1 & 2) to gather information from teachers who had limited experience of videoconferencing, and also from those who were very experienced. Further interviews were conducted during the course of the research project with individuals selected to illuminate particular aspects of using videoconferencing and low-latency technologies. Some interviews were conducted face-to-face, but most were conducted via videoconferencing. The interviews lasted between 20 to 60 minutes, with most lasting on average 30 minutes, with a little time before and after for social chat. Table 8 contains the full list of interview participants and appears as Appendix H.

Secure data storage was approved by the Ethics Committee of the RCS. The interviews were recorded on a password protected iPhone using voice memo function. The recordings were then transferred to a password protected laptop computer and converted to MP3 files for transcription. Earlier transcriptions were made with the assistance of the 'oTranscribe' app; later transcriptions were made using the dictate function on Word and more recently, the Otter.ai app. Transcriptions were kept on the same password protected laptop computer for later coding and analysis.

### 3.3.2 Observation

Due to its versatility, observation was chosen as the most appropriate method of data collection for Study 3, understanding the frequency of use of playing together in face-to-face lessons (Simpson and Tuson, 1995). According to Yarbrough (1992, p.90), 'systematic observation begins with thorough definition of observable, measurable behaviour. Observation tools are reliable and valid dependent measures for use in behavioural or experimental designs'. Observation was also used during four lessons conducted by a brass teacher via high-quality videoconferencing.

Two trials of LoLa used for remote recording sessions were observed in Edinburgh Napier University's Music Department (Study 12). Notes were taken of the dialogue between the musicians and the technicians in between recording takes, and observations were recorded on the interactions between the musicians using LoLa.

### 3.3.3 Trials and semi-structured interviews from the SWING project (Study 14)

I collaborated with the Association Européenne des Conservatoires, Académies de Musique et Musikhochschulen (AEC) on the Synergic Work Incoming New Goals for Higher Education Music Institutions (SWING) project, a strategic partnership running from September 2018 until September 2021 funded by the European Commission's Erasmus+ programme. This is reported as Study 14 in Chapter 7.

The project aligned with my own goals in seeking to understand the experience of using LoLa technology for instrumental music teaching, and I assisted in developing the interview prompts with Dr Stefan Gies, the Chief Executive Officer of AEC. The LoLa trials took place in early 2019; an initial questionnaire was then sent to participants and is attached at Appendix F (p.274). The interviews were conducted later in 2019 by three different

researchers, and the interview transcripts were made available to me in January 2020.

The interview participants were recruited by the AEC from conservatoires in Austria, Italy and Slovenia. Participants were selected by their respective institutions and the interviewers. Participants were informed about the intended use of the research, and they were also assured that their participation was voluntary, and that anonymity would be preserved. A letter from Dr Gies is attached (Appendix G), giving assurance that prior to the interviews, verbal consent was gained from each participant for the anonymised data to be used as part of the SWING project and any related third-party projects.

### 3.3.4 Survey of responses of instrumental music teachers on social media forums to using videoconferencing during lockdown (Study 4)

This study monitored the experiences of instrumental music teachers, many of whom had rapidly transitioned to teaching via videoconferencing following the COVID-19 lockdown. The teachers posted in several teaching forums on the Facebook social media platform and gave me access to the shared concerns of hundreds of teachers, something that under normal circumstances would have been very difficult to achieve. The conversations explored the experiences of teachers new to teaching via videoconferencing, with guidance and tips given by more experienced teachers. Whereas the study was supplemental and not part of my original planning, I felt it made a valuable addition to my dataset, and it would have been detrimental to my thesis were it not included.

From *Social media: a guide to ethics* (Townsend and Wallace, 2016):

> Social media platforms are now utilised as key locations for networking, socialising and importantly, for reflecting on all aspects of everyday life. Such online spaces therefore hold vast quantities of naturally-occurring data on any number of topics [...] This provides researchers with a huge opportunity to gather data that would otherwise have taken much time and resource to obtain (ibid., p.3).

> Social media platforms are increasingly used by many as a means of communication, sharing information and […] the sharing of attitudes and behaviours on a huge breadth of topics. It is this user-generated content that presents such a valuable opportunity to researchers (ibid., p.5).

Conversations were copied and pasted to Word documents and held securely on password protected devices. All posts and comments were anonymised; no direct quotations were used, and all identifying features were removed to maintain user privacy and confidentiality. No sensitive or controversial topics were included. The dataset was then coded and analysed, relevant themes identified, and the dataset was synergised with my existing data.

I identified the following risks:

- whether the use of the data breached Facebook's legal terms of use;
- whether the privacy of research subjects could be maintained;
- how the research data were stored and secured;
- whether informed consent could be reasonably obtained from a large and diverse number of users.

I consulted the Facebook Terms of Service (Facebook, 2020) and by anonymising the data, I satisfied Facebook's legal terms. Informed consent, along with the right to withdraw consent, is a critical component of traditional research design. However, social media users have already agreed to a set of terms and conditions, and whether posting or commenting in public or private groups, they are aware that other users will be observing and interacting with their comments (Townsend and Wallace, 2016). Nonetheless, when using posts and comments for research purposes, the key considerations must be the safety of users and their right to privacy. Therefore, all data were treated as private and confidential.

### 3.3.5 Autoethnography

According to Chang (2016), autoethnography 'could mean different things to different people' (Chang, 2016, p.46), but for the purposes of this study, I use

a definition of autoethnography as a research method that uses personal experience to describe and interpret cultural practices (Adams et al., 2017).

By participating in the trials as a practitioner-researcher, my knowledge and experience was helpful in selecting and engaging with participants. As a social insider with an ‘emic’ perspective (Markee, 2012), I could relate to experiences that participants shared with me, allowing me to ask further pertinent questions during the interviews.

Autoethnography is sometimes criticised as a research method for containing possible biases. Reed-Danahay (1997) describes three possible problems:

- Is the autoethnographer a social insider (emic), or an outsider (etic) of the practice being investigated?
- Is the researcher’s voice more prominent than that of the research participants?
- Cultural displacement: research participants may have been displaced from their natural environment for a variety of reasons.

I acknowledge these problems, and I am aware that my experience and background will inevitably affect my perception of participant narratives. Whilst recognising that I may carry certain biases and opinions (whether conscious or subconscious), my experience has been helpful in generating productive areas of inquiry.

My training and professional performing experience is primarily in orchestral percussion, and I therefore have the greatest knowledge and experience in this area. However, I also have experience of performing and teaching in different musical styles and genres including popular music, traditional/folk, jazz, Brazilian samba and Japanese taiko drumming. I have also had instruction in a variety of other instruments, and I am familiar with the technical difficulties associated with each of the main instrument categories including voice. This gave me greater insight when interviewing participants,

and allowed me to discuss issues with them knowledgably, and within their cultural milieu.

## 3.4 Data coding and analysis

Deductive coding and template analysis (King, 2016) was selected as being the most appropriate method for analysing data from the semi-structured interviews. Template analysis offers several advantages over other qualitative data analysis methods such as grounded theory and interpretative phenomenological analysis (IPA). These methods tend to have a 'bottom up' approach, that is, there are no 'a priori' assumptions about which themes will be most important (ibid.). Thus, template analysis can be more efficient and time-saving as it allows the researcher to set up a template or framework with themes in advance, and then further refine it as necessary. The interviews all followed a similar schedule, so a set of themes already existed, and the different participant responses were then added to the template.

Two challenges associated with template analysis are that by focusing only on data that fits the a priori themes, material may be overlooked that does not fit within the themes, and the researcher may also fail to recognise when an a priori theme is not adequately addressing the data (ibid.). To try and mitigate these potential problems, the interview framework allowed participants to express views on other aspects not included in the a priori themes. Later interviews were analysed in a similar way, but as participants with different experiences were interviewed, more themes were added.

The 17 interviews from the SWING project were analysed and coded differently to the previous interviews. Due to the interviews being conducted by three different researchers, inductive coding was used (ibid.). On the first pass, each transcript was read through in its entirety with no notes being taken. On the second pass, codes were created to fit particular words or themes. On the third pass, codes were assigned to different parts of the text and these text parts were then grouped together into themes and summarised. The process continued with each transcript, creating and

applying more codes as necessary until the whole sample set had been coded and analysed. From there, the codes were added to a hierarchical coding frame, showing major themes with subthemes attached.

## 3.5 Considerations and factors affecting the research

### 3.5.1 Participant selection

A broad range of participants from different instrumental disciplines and different levels of education, including participants from aged 9 to adults, and from different genders, were included to find points of consonance and dissonance. Through the interview data, trials, and subsequent discussions with participants, congruent themes emerged. As suggested by Angen (2000), I have also considered alternative explanations for the research findings, which will be explored in each of the discussion sections of the findings chapters.

Convenience sampling, also known as availability sampling (Waterfield, 2018), was used to select participants in Studies 1–3, 5–6 and 8–9. In this method, the selection of participants was based on their ready availability, which may be due to geographical proximity (such as colleagues, fellow students, etc.). Since the research was investigating remote interaction, geographical proximity was not so important in all of the studies, and personal contacts were invited to participate based on their personal insights and experience, rather than their physical location.

Convenience sampling has practical advantages in terms of travel, cost, and time savings, but this can result in certain biases, such as the participants not being representative of a constituency or a population through sampling error and under-coverage (ibid.). However, given that the research was mostly qualitative, I was more concerned with a participant's experience and its relevance to the aims of the study, and I did not consider it necessary, or even possible, to try and achieve a strict representation of all categories of teachers and students. This might affect the results by not including instrumental

categories such as organ, where playing with others is perhaps not as frequently used in lessons as for example, violin.

Nonetheless, in order to try and mitigate the shortcomings of convenience sampling, I included a wide range of participants including teachers, students, parents of students, technicians, and conservatoire administrators. I drew these participants from a range of instrumental and vocal disciplines, and across different levels and types of education: conservatoire, university, and schools in both the state and private sector, and also private students. I also included participants from a range of locations, both within the UK and internationally. To try and account for 'outliers', or data that I may not have been able to gather based solely on personal contacts, I included data from specialist instrumental music teacher social media forums, which gave me access to a much larger sample size than would have been possible through more conventional research methods.

Whilst recognising the inherent problems with making generalisations based on these limited research samples, I feel that the datasets complement each other, and provide a broad as well as an in-depth analysis of the experience of using videoconferencing and low-latency technologies.

### 3.5.2 Validity and biases

Validity was addressed by being aware of possible biases including reactivity, respondent bias, and researcher bias (Lincoln and Guba, 1985). There was the potential for respondent bias in the interviews, but the interview prompts asked participants for their individual and subjective responses to the use of technology, and as such, there were not 'true or false' answers. Therefore, reactivity and respondent bias were not considered to be significant factors.

For the SWING interview data, by being separate from the interview process I was able to maintain a degree of objectivity and thus eliminate the possibility of influencing the interview subjects. In coding and analysing the data, there was the potential for researcher bias; however, the coding was inductive, and

a summary of what was actually said was kept, which helped to control any researcher prior assumptions. In assessing the suitability and potential of LoLa for instrumental music teaching in conservatoire settings, I looked at the interview transcripts through my own lens as an experienced music educator and a researcher.

Robson (2002) suggests other strategies to further remove threats to the validity of the data including triangulation, prolonged involvement, and keeping an audit trail. Datasets were triangulated from three different groups of participants in three different countries. I was immersed in the coding and analysis of the data for a prolonged period of time which further reduced the risk of bias. An audit trail was maintained showing each stage of the coding and analysis process and I referred back to this when making some revisions to the coding.

I recognise that the music conservatoire is deeply rooted in a tradition of notated music, but in my research, I did not prioritise notated music over improvised music or music taught aurally. I purposely sought participants from a wide variety of music genres and instrument types. For example, one of the LoLa trials involved myself and a jazz saxophonist improvising together. I also conducted an interview with a percussion student who travelled to India to study tabla drumming so as to gain an immersive face-to-face cultural experience that they could not gain via videoconferencing.

When selecting quotes from the interview transcriptions, I have made editorial decisions which are inevitably open to tacit biases (Fleming, 2018). However, I have attempted to include responses which give different perspectives and I have also attempted to foreground the voices of the research participants.

### 3.5.3 Ethics and academic integrity

I acknowledge that the choices that I have made in the research process have both political and ethical considerations. For example, there is the possibility of the research being used to justify the use of videoconferencing and low-

latency technologies by institutions and organisations wishing to save money, particularly in current circumstances, when face-to-face interactions may in fact be more appropriate for some students. On the other hand, the research could also be used to highlight the benefits of adopting these technologies, and students may gain access to musical interactions that were previously unavailable.

The studies have adhered to the ethical guidelines suggested by Bulmer (2008) and have been approved by the Research Degrees Committee of the Royal Conservatoire of Scotland. I have carefully considered my sample groups, including whether the research would be helpful or harmful to the participants. I have attempted to present the participants' opinions and statements fairly and accurately, and I have also attempted to carry out the research projects in a respectful manner. With the exception of Study 4 (for which separate ethical approval was granted by the Ethics Committee of the Royal Conservatoire of Scotland), participants were informed about the intended use of the research, and they were also assured that their participation was voluntary (Kokotsaki, 2016). A Participant Information Sheet is attached at Appendix A, and a Participant Informed Consent Form is attached at Appendix B.

Two participants who are world-leading experts in their field gave permission to be named in this thesis. Given their unique positions, it is possible that they may have been identifiable from a description of their role, and adding their names gives additional credibility and authenticity to the research. The rest of the interview participants were assured anonymity, and approval was granted by the Ethics Committee of the Royal Conservatoire of Scotland.

## 3.6 Discussion

The autoethnographic teaching trials gave me practical experience of using videoconferencing both as a teacher and a learner. This in turn gave me a greater insight into the pedagogical, administrative, and technical challenges associated with videoconferencing when subsequently interviewing

participants. Having built up experience of teaching via videoconferencing, it was useful to have a baseline to work from when assessing the experience of teaching in the low-latency trials.

Another advantage of the autoethnographic videoconferencing teaching trials was that by reflecting on my own experiences, I had ready access to data, a problem that became apparent when trying to organise larger-scale low-latency trials later in the research. A possible objection to using autoethnographic data is that by analysing my own personal narrative, the research could be limited in its conclusions, but as reported by Bochner and Ellis, this limitation may not be valid, as 'if culture circulates through all of us, how can autoethnography be free of connection to a world beyond the self?' (Bochner and Ellis, 1996, p.24). Furthermore, the autoethnographic research formed only part of the total datasets.

For Study 8 with myself in the role of learner, I found a wide variation in teaching styles between the different teachers. I noted these differences in a reflective journal, together with how each teacher dealt with the various technical and pedagogical challenges of online teaching. Some teachers sent bulleted notes during the lesson, others posted recordings from the lesson privately on the Vimeo video-sharing platform, and others referred me to print and online resources. I also made copious notes during and after lessons.

For the videoconferencing trials with myself in the role of teacher (Studies 5–7), I found it difficult to actively teach the lesson whilst also trying to make detailed notes, and I soon abandoned this method. Instead, I made short notes during the lesson and following each lesson, I also reflected on the various challenges we encountered and recorded these in a journal. Thus, there was an unevenness in how the data were recorded, depending on my roles as teacher and learner.

The interviews from the SWING trials were effective in providing a rich source of qualitative data from a variety of different perspectives: those of teachers, students, and technicians from three different countries. The inclusion of this

data was potentially problematic, as although I had collaborated with the SWING project team on the formulation of the research questions, I did not interview the participants. However, not being directly involved with the interviews was in some respects advantageous as I was able to maintain a degree of objectivity when analysing and coding the data.

Observation was an effective method of obtaining the data for Study 3, investigating the frequency with which teachers and students played together in face-to-face lessons. The method was simple, and other than my presence in the lessons being potentially off-putting to the teacher and the students, there was no further disruption to the lessons. The analysis was also simple and only required totalling up the tallied amounts for each interaction. Similarly, observing the LoLa recording sessions (Study 12) yielded important data as to the effectiveness of the technology. Since recording engineers were also present in the studio, there was minimal disruption to the musicians caused by my presence.

These studies, and the interpretations that are drawn from them, are located in two different times and contexts: before, and during the COVID-19 pandemic. They are therefore open to further interpretation and negotiation in the light of our new social reality, which is as yet unknown.

This chapter has described the various methods deployed and the rationale in choosing them to answer the research questions, together with considerations of ethics, validity, and bias. These studies are summarised below in Table 1, with a brief outline of the research methods, specific research questions and their relation to the main research questions (shown as: R1, R2, R3) and themes emerging from each study.

The following chapter reports on findings from the videoconferencing phase of the research and reports on relevant interviews with teachers and students, and also a study demonstrating the importance of playing together in instrumental music lessons.

| | Study No. | Description | Research methods | Specific research questions | Themes emerging |
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| **Chapter 4** | | **Videoconferencing—teaching trials and interviews** | | | |
| 4.2 | Study 1 | Initial study of instrumental music teacher attitudes to technology | Semi-structured interviews | Investigate how school instrumental music teachers are using technology in lessons.<br><br>Evaluate what was already taking place and monitor new developments (R2)<br><br>Evaluate music teachers' attitudes to using technology and videoconferencing. | Teachers and students were enthusiastic about using technology in lessons.<br><br>Smart devices were widely used in lessons, including making audio and video recordings.<br><br>Some uncertainty from music teachers about using videoconferencing for teaching. |
| 4.3 | Study 2 | Study of teachers and students experienced in the use of videoconferencing | Semi-structured interviews | Investigation of:<br><br>the rationale for using videoconferencing;<br><br>what changed in the quality of the experience in lessons between environments (R1);<br><br>whether some elements of music instruction are more or less effective in these environments (R2);<br><br>the challenges that teachers experienced using videoconferencing (R3);<br><br>how those challenges may be mitigated (R3). | Each environment had its own advantages and disadvantages.<br><br>The quality of the experience depended on a variety of factors including technical equipment and stakeholder attitudes.<br><br>Videoconferencing expanded the possibilities for music lessons. It was convenient and avoided participants traveling; it facilitated lessons where face-to-face provision was not available; it broadened the reach of Higher Education, including auditions, masterclasses, trial lessons and supplementary lessons; it made the sharing of resources easier.<br><br>Videoconferencing lessons were intensive and tiring due to hyper-focus. More time was required for developing teaching materials. Time in lessons was distributed differently.<br><br>There were mixed views on the importance of the visual element.<br><br>Teachers benefitted from professional development opportunities in watching students working with other teachers in masterclass settings via videoconferencing.<br><br>Many teachers were frustrated at not being able to play together with students in the videoconferencing environment. |
| 4.4 | Study 3 | An investigation into the frequency with which teachers and students perform together in face-to-face instrumental music lessons | Observation | Investigate the frequency with which teachers and students played together in co-present face-to-face instrumental music lessons. (R2) | Playing together forms an important part of face-to-face instrumental music lessons.<br><br>The most frequently observed event was that of the teacher and student playing the same part together at the same time. |
| 4.5 | Study 4 | Music teacher responses to COVID-19 on social media forums | Survey of responses on social media forums | Understand how instrumental music teachers were adapting their face-to-face teaching to the online teaching environment during COVID-19 (R1, R2). | After initial uncertainty, many teachers were surprised at how easily they adapted to online teaching, and plan to retain some elements in the future.<br><br>Concerns about safeguarding of teachers and students when working from home studios. |

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| | | | | | Need for an audiovisual system that facilitates playing together, combined with high-quality audio. |
| **Chapter 5** | | **Autoethnographic studies: my experience as a teacher and a learner** | | | |
| 5.2 | Study 5 | Teaching an adult marimba student | Autoethnography; semi-structured interviews | Trial using videoconferencing to teach four-mallet technique (R1, R2, R3). | The adult student made significant progress in a difficult technique in lessons via videoconferencing.<br><br>Videoconferencing improved access to lessons, and increased productivity in lessons.<br><br>Poor internet connections occasionally caused disruption to lessons. |
| 5.3 | Study 6 | Teaching two beginner drum kit students | Autoethnography; semi-structured interviews | Test the complexities of teaching young beginner students via videoconferencing (R1, R2, R3). | Two younger students made significant progress in lessons via videoconferencing, but both preferred face-to-face lessons.<br><br>Poor internet connections resulted in switching to audio-only mode to improve connectivity. The presence of parents to assist with setting up technology was important.<br><br>Sharing of online resources to make them accessible to younger students required adjustment.<br><br>There was some debate on whether it was important to meet students, particularly younger students, face-to-face before beginning lessons.<br><br>It is important to be able to diagnose physical and postural problems before they cause injury to learners. Therefore, the visual element is important. |
| 5.4 | Study 7 | Teaching school students online during COVID-19 | Autoethnography | Report on the mass 'emergency pivot' to online teaching during COVID-19 (R1, R2, R3). | The emergency pivot forced immediate changes without prior planning, which would have previously taken a long time to test and implement.<br><br>For some students, the lessons proved highly successful, with some making greater progress than I would normally expect.<br><br>There was a digital divide, with some students not able to access lessons due to poor connectivity, or difficult home circumstances. |
| 5.5 | Study 8 | Online lessons as a learner | Autoethnography | Report on my own experience of online lessons (R1, R2, R3). | Online technologies increased my access to a wide variety of teachers in different locations.<br><br>MOOCs offered a useful model for sharing materials in my own teaching practice.<br><br>I was able to participate in online communities of practice, which led to real world practice and performance opportunities. |

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| | | | | | Hybrid lessons using face-to-face and online lessons offers a rich mix of the benefits and convenience of both environments. |
| **Chapter 6** | | **Initial LoLa trials: primarily technically focussed** | | | |
| 6.2 | Study 9 | Test of concept: LoLa in compression mode at Edinburgh Napier University | Autoethnography; semi-structured interviews | Investigate how the various settings of LoLa can be adjusted to achieve an acceptable musical experience during a lesson (R1).<br><br>What is the minimum bandwidth required to achieve an acceptable musical experience? (R3) | Participants found the LoLa platform superior to Skype and were able to perform duets together.<br><br>LoLa could be used in compression mode with acceptable audio and video quality at just 18 Mbps. |
| 6.3 | Study 10 | LoLa trial between RCS and Edinburgh Napier University | Autoethnography; semi-structured interviews | Check the minimum bandwidth required to successfully allow synchronous real-time musical collaboration via LoLa between remote locations (R1, R3).<br><br>Experiment with different permutations of LoLa settings to determine the importance of the synchronisation between audio and video for users (R1, R2, R3). | Bandwidth requirements as low as 16 Mbps.<br><br>Participants agreed the musical experience using LoLa was superior to standard videoconferencing.<br><br>When audio and video elements were in synchronisation, they were used for visual cues.<br><br>Setting up equipment took longer than for a standard videoconferencing lesson.<br><br>Discovery that LoLa functioned with the institutional firewall, albeit with audio artefacts. |
| 6.4 | Study 11 | Learning and teaching demonstration using LoLa between RCS and Edinburgh Napier University | Observation | Trial the newly acquired LoLa system at RCS with teachers and students who had not previously used LoLa, and to get participants and audience feedback on its use (R1, R2, R3). | Participants reported positive experiences using LoLa.<br><br>The teacher was able to play with students in real time to assist with phrasing, timing, and articulation, and to give commentary during the performance, thus more closely matching the experience of face-to-face lessons than standard videoconferencing platforms.<br><br>Audience discussion about expanding the possibilities at RCS for rehearsing, teaching, examining, and auditioning using LoLa. |
| 6.5 | Study 12 | LoLa as a facilitator of remote synchronous recording | Observation | Observe LoLa used for recording sessions between remote locations up to 3,000 miles apart (R1, R2, R3). | Musicians were able to interact in real time and successfully record together at distances of 3,000 miles.<br><br>LoLa facilitated social interactions between recording takes, making it superior to an asynchronous recording session.<br><br>The video element was important and was used for giving and receiving visual cues. |
| 6.6 | Study 13 | Interview with Justin Trieger of New World Symphony Music School | Semi-structured interview | To understand the history and background of distance learning, and possible future directions, at a world-leading music establishment from a leading authority in the field (R1, R2, R3). | LoLa is the only audiovisual tool available for playing synchronously, and can operate audio at better-than CD quality.<br><br>The LoLa software is simple to use and has a simple interface. The biggest technical issues are |

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| | | | | | normally network related and in the initial deployment stage.<br><br>Studio environments require planning for different instruments.<br><br>Preference for learning in person where possible, with online instruction used as a supplement.<br><br>Prediction that we are at the start of a paradigm shift, with increasing adoption of technology and some universities moving to virtual attendance only. |
| **Chapter 7** | | **Evaluating LoLa in European conservatoires: the SWING project—different perspectives from teachers, students, and technicians** | | | |
| 7.1 to 7.3 | Study 14 | The SWING project | Analysis of semi-structured interviews | Explore different aspects of LoLa in conservatoires, including the rationale for its use, especially with relation to the Erasmus+ programme; pedagogical considerations; the physical and virtual environment; attitudes and perceptions to using LoLa (R1, R2, R3). | LoLa facilitated instrumental music lessons between conservatoires in different countries.<br><br>Participants overcame their initial scepticism and were impressed by the audio and visual quality of the platform, and the ability to play together in real time. LoLa could be used as a supplement to face-to-face lessons, though not a replacement.<br><br>New possibilities for collaborative learning, co-teaching, examining, and opportunities for students to learn, rehearse and perform with teachers and students from different countries and cultures.<br><br>Teachers can benefit from observing their own students learn from different teachers.<br><br>The loss of physical presence is an ongoing concern. Requests for further improvements to the audio quality, including spatial sound.<br><br>Studio environments require planning for different instruments.<br><br>The cost of LoLa and the need for a high-bandwidth network, technical support and associated infrastructure may be prohibitively expensive for smaller institutions. |
| **Chapter 8** | | **Low-latency audio-only: the JackTrip platform—teaching trial and interviews** | | | |
| 8.3 | Study 15 | JackTrip trial | Autoethnography; semi-structured interviews | Test whether the audio of JackTrip could be used in combination with the visual element of a videoconferencing system to give an acceptable user experience (R1, R2, R3). | JackTrip gave an experience similar to LoLa, though the lack of synchronisation between audio and visual elements was distracting.<br><br>In early 2020, concerns about the ease of setting up JackTrip in educational establishments (now easier in 2021). |

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| 8.4 | Study 16 | Interview with a university vocal teacher | Semi-structured interview | To understand the teacher's experience of using JackTrip on a standalone device, and their impression of the audio quality and the overall usability of the system (R1, R2, R3). | JackTrip can be operated on inexpensive devices via standard networks, and it can also facilitate large ensemble rehearsals and performances.<br><br>Low-latency was not 'no-latency'. Issues with setting up the technology, including tethering the device to a phone.<br><br>Issues reported in balancing the sound between three different acoustic spaces. |
| 8.5 | Study 17 | Interview with Sarah Weaver, Network Arts practitioner | Semi-structured interview | To understand more about the development of JackTrip, the technical problems affecting usability, and how JackTrip was being used in education (R1, R2, R3). | JackTrip has high-quality, uncompressed, low-latency, multi-channel, two-way audio.<br><br>Inherent problems with playing 'steady-beat music' over networks.<br><br>Pre-pandemic, JackTrip mainly used for Network Arts; at start of pandemic, high demand from musicians for playing together led to rapid development of JackTrip.<br><br>Technological advances include the development of cloud-based services. Visual element unresolved.<br><br>Development of training courses to assist educators with using JackTrip. |

*Table 1: Summary of research studies, showing methods, research questions, and themes emerging.*

# Chapter 4: Videoconferencing

## 4.1 Introduction

This chapter is organised into six sections: introduction, data from four studies and a discussion section. The four studies presented are:

- Study 1: an initial study with five instrumental music teachers, exploring their attitudes to the use of technology;
- Study 2: a larger and more in-depth study with 12 teachers and students experienced in the use of videoconferencing;
- Study 3: an investigation into the frequency with which teachers and students perform together in face-to-face lessons;
- Study 4: a survey of music teacher responses on social media forums to teaching online during COVID-19.

The majority of the research presented in this chapter was carried out prior to the COVID-19 pandemic, but as discussed later in this chapter in Section 4.6, the attitudes of many instrumental teachers have since changed as they have become accustomed to teaching via videoconferencing.

The research questions are:

- Research question 1: What changes in the quality of the interactions and the learning and teaching experience in lessons between face-to-face, standard videoconferencing, and low-latency environments?
- Research question 2: Are some elements of music instruction more or less effective in these different environments?
- Research question 3: What are the barriers to using these technologies in educational settings and how can these be overcome?

The studies were conducted in several phases. Study 1, an initial small-scale study was carried out in 2015 to survey the attitudes of instrumental music teachers working in schools towards using technology, including videoconferencing. Study 2 was conducted between 2015 and 2021 with teachers and students already experienced in using videoconferencing in

schools, HEIs and private practice, to explore their views on the opportunities, benefits, and limitations of using videoconferencing technology. Study 3, carried out in 2016, measured the frequency with which teachers in schools performed together with students during the face-to-face instrumental music lesson. Study 4 provided a dataset for the period immediately following the COVID-19 lockdown of March 2020. This examines comments from instrumental music teachers posting on specialist social media forums seeking advice on using technical and pedagogical strategies for the rapid pivot to online teaching.

## 4.2 Study 1: Initial study of instrumental music teacher attitudes to technology

### 4.2.1 Introduction

The aims of Study 1, conducted in May 2015, were:

- to find out how instrumental music teachers working in schools were using technology in their lessons ;
- to evaluate what was already taking place in lessons and to monitor new developments;
- to evaluate teachers' attitudes to using technology, and more specifically, videoconferencing;
- to try out the practicalities of a small-scale research project.

Five instrumental music teachers were interviewed, each from a different instrumental discipline: percussion, guitar, upper strings, keyboard, and brass.

| Participant | Instrument | School setting |
|---|---|---|
| **A** | Percussion teacher | Private school, ages 5–18 |
| **B** | Guitar teacher | Secondary |
| **C** | Upper strings teacher | Primary and secondary |
| **D** | Keyboard teacher | Primary, secondary and special needs |
| **E1** | Brass teacher | Primary and secondary via videoconferencing |

*Table 2: List of participants in Study 1*

The teachers worked in primary and secondary schools in different parts of Scotland. A list of participants is shown in Table 2.

Participants were selected based on my knowledge of them using technology in their teaching, and also for their ready availability (Waterfield, 2018). Interviews were conducted in person and via videoconferencing. Teacher E made a short video as a response to my written questions. I subsequently observed Teacher E using videoconferencing and also interviewed them; I have noted this in Table 8 as E1 and E2 to show the two separate events.

A full interview framework is included at Appendix C. Questions included:

- What technologies are instrumental music teachers currently using?
- How are students responding to the use of technologies in the classroom?
- What are instrumental music teachers' views on, and experiences of, videoconferencing?

The interviews were recorded, transcribed, and then coded deductively using the following pre-set headings: types of technology; teacher attitudes; student responses; desired improvements in technology. The data was then analysed using template analysis. The following themes emerged and aligned closely with the initial coding:

- different types of technology used in the instrumental lesson;
- technology for empowering teachers and students;
- student responses to using technology;
- the use of videoconferencing in instrumental music lessons;
- possible future developments.

### 4.2.2 Different types of technology used in the instrumental lesson

Participants reported using apps on smart phones and tablet devices. These ranged from functions often found in a music lesson such as tuners and metronomes (Teacher B, and echoed by Teacher C), through to more

sophisticated apps such as ‘Speedshifter’ (for playing backing tracks at a variety of tempi), iReal Pro accompaniment software, and music notation apps on the iPad.

Teacher A described using digital copies of sheet music published by Rockschool (Rockschool, 2021) on an iPad that synchronises with a backing track. This highlights the bar being played, as well as facilitating changes of tempo, and highlighting sections that can be ‘looped’ for repetition.

Teacher A described the benefit of using an electronic drum kit in their teaching room:

> I got the department to purchase an electronic drum kit just so that we could use headphones and not be so concerned about volume all the time, so that they [students] felt they could express their dynamic range without being embarrassed about the volume.

Teacher A then explained that they used their iPad in conjunction with their electronic drum kit to record student performances for immediate playback and review during the lesson. They also used the iPad in conjunction with the app ‘Jammit’ (since discontinued). Students recorded their own version of a song and shared it online using the Jammit app, from where the recording was assessed, scored, and given a worldwide ranking: ‘I think competition added into music in this way does add a little bit of a community to my students’.

Audio and video recordings were made during lessons on smart phones and tablets by teachers and students. Some students recorded their teacher demonstrating a technique, a study, or a piece for review between lessons. Teacher B explained:

> During the lesson they have filmed either my right hand or my left hand doing something in particular passages of the picking pattern they can’t quite get […] it’s unbelievable when I think about my own experience at school that students can [now] do that.

Teacher C described making a video recording of a student's performance in the lesson to give immediate feedback on a specific element such as pitch, along with modifications to be made:

> I have found recording quite useful in lessons for pupils that maybe don't have a great sense of pitch, or they are unable to connect what they can hear in their head with what actually comes out of the instrument, so they are hearing it as a third person.

Teacher C also described using audio recordings of ensemble rehearsals to motivate and encourage students:

> It's also helped in school groups when we're quite near a concert, and it could be because I think there are things to improve, or it could be because I want them to realise they actually sound quite good. It's just so that they can hear it as an audience member, or how I hear it in a lesson.

Teacher E described using recordings to give feedback on postural or embouchure adjustments: 'I record pupils and let them analyse what they've done […] we tend to get them to use a close-up of their embouchure using their device'. Teacher D allowed their students to video demonstrations of close-up views of finger work on the keyboard or accordion using the student's own device for review between lessons.

Teacher E described students using apps such as GarageBand to record themselves as one part of a duet or an ensemble, and then playing other parts along to their recording:

> I get pupils to record the second part of a duet and then play the first part over the top of it. It's brilliant for me to get them in time, in tune, and it really does force them to think about what they're doing […] If they've got access to GarageBand, we do a lot of four-part recordings, so I'll give them a quartet to work on and put together, and I do that from very early on.

Teacher C described using recordings as a means of establishing progress:

> It's quite interesting maybe to listen back to an old recording and compare the two side by side, maybe if it's just even a passage […] It's sometimes good a few weeks apart from when they've started something, and you let them hear the finished product at the end, I think they can be quite satisfied.

Teacher B also discussed students keeping audio journals in an electronic portfolio for sharing with teachers and family members. All of the teachers were very aware of potential safeguarding issues with storing recordings of students, particularly with younger students. Teacher C commented: 'I just delete them straight away. I let the pupils see me do it. Or sometimes they record it on their own phone if it's a secondary pupil'.

The comments revealed that smart phones and tablet devices were frequently used in lessons for making audio and video recordings. This can greatly assist students in reviewing material between lessons; however, at the time of the study in 2015, smart phones and tablets were not so ubiquitous as they now are, which may have potentially put some students at a disadvantage (Biasutti et al., 2021).

### 4.2.3 Technology for empowering teachers and students

The second theme was a general impression that teachers found technology empowering as it made lessons 'run more smoothly and seamlessly' (Teacher A). This included using the Internet as a resource for bringing additional content to lessons, including YouTube clips and online links to historical figures in music: 'my students now understand the key figures in drumming more than they ever did before' (Teacher A).

Teacher B described how their students used self-directed learning to assist their classroom learning:

> I actually find that students find YouTube videos themselves all the time. If, for example, you get the Rockschool pieces, there are large passages where there is a solo. You tell them what scales to use to work out their improvisation and maybe show them a couple of ways to start it off. A lot of time during the week they will go home and

> look at previous tutorials that have been put up on YouTube and sometimes come back with carbon copies of the solos.

However, Teacher C noted that despite the relative ease of using the Internet between lessons to investigate artists and performances, students may not always do this, and it will depend on a student's motivation.

Teacher E described how technologies such as the SmartMusic online platform (SmartMusic, 2021) can encourage sight-reading:

> Pupils are sight-reading a lot [using SmartMusic] and it means that in band rehearsals, my students can come in, sit down, and read very quickly, and their level of progression is noticeably different. It is hard for the students initially, but used properly, the technology is making a huge improvement […] in theory, the level of playing that we see coming through should be infinitely higher.

The Internet provides teachers with a wealth of opportunities for sharing multimedia resources with students, but as noted above by Teacher C, not all students are necessarily motivated to find additional materials to support their learning. Furthermore, given the overwhelming amount of material available online for students to explore, teachers have a role in curating high-quality content.

Teacher E suggests that due to the rapid advances in learning technology, the availability of different apps, and the ease of availability of material to support learning via the Internet, students should be progressing more rapidly. However, learning to play a musical instrument takes time and patience, and the knowledge and experience of an expert teacher is crucial in guiding students on repertoire and technical exercises appropriate to their age and stage of development.

### 4.2.4 Student responses to using technology

I asked participants how students had responded to using technology. Teacher A commented:

> Very positively, and they think nothing of it because they use their smartphones and devices so often to check things out on the Internet that it's nothing to them. In fact, they'd probably find it strange if you didn't use it! I think they're just as au-fait with how the technologies work, but sometimes not aware that those technologies are there. I feel that I'm the one that's bringing the technologies to them, but once I've shown them they exist, they know how to use them.

The above comment supports the idea that teachers have an important role in advising students on appropriate technologies for them to use.

Teacher D commented 'Students love any opportunity to be in front of screens, in fact they would rather do it electronically if they can, their devices are always their first source'. Teacher E commented: 'it's just part of their life and they adapt to it incredibly quickly and they use it. And for me, it really enhances a lesson.' Teacher D remarked on students' increased motivation: 'They are certainly more motivated through using electronic devices and technology. That's the way to encourage them to practise'.

Despite the enthusiasm of the teachers for using technology and their belief that students also enjoy using technology, in my experience, not all students are so enthusiastic. Some students struggle with using technology, and some parents are disapproving of their children spending a lot of time in front of a screen. Having a smart device in a practice room can certainly be useful when using practice apps, playing to backing tracks, etc., but they can also be distracting unless social media and message notifications are turned off.

### 4.2.5 The use of videoconferencing in instrumental music lessons

The teachers in this initial study had a mixture of experience of teaching via videoconferencing. Teachers A and D had a little experience of using videoconferencing in lessons, Teacher E was highly experienced, while Teachers B and C had not yet used it for instrumental teaching.

Participants reported concerns about the loss of physical presence and a physical disconnection from students. Teacher C was concerned about using videoconferencing for beginner string students, feeling that it was essential to be able to adjust posture in the early stages of lessons:

> It's a very tactile sort of environment teaching strings. And it's not necessarily touching their hands, although you might prod and poke, or manipulate fingers a little bit, it could even just be when they've got a nice bow hold, pulling the end of the bow right to the tip, and then back up, so that they have use of the whole bow. You're playing puppeteer quite a lot in lessons like that. I don't think I'd be able to get the kind of results that I would want, because I think if you don't set those foundations up in the first couple of years, the young student will never really be any good at it. So, I think doing those stages by videoconferencing would be really counter-productive.

Teacher A commented on the importance of being physically present: 'I think you can tell when someone is engaging with you from their body language and their demeanour, more than [...] sometimes, what they actually play'.

Teacher C also discussed the physical disconnect in relation to tuning string instruments, particularly with younger students, feeling that: 'it would be impossible to remedy that, unless there was someone else there, which would defeat the purpose I suppose'.

Teacher B described other potential problems in addition to tuning instruments, such as adjusting tone production and physically correcting postural problems remotely.

> Holding the guitar is difficult; getting the student to realise what they're doing wrong physically, sometimes I would try and mirror with my own body what they were doing, and I don't know how well that would come across in Skype […] And specifically for electric guitar, getting the tone on the amplifier is not maybe something that you would get over an internal microphone on a computer exactly how pleasing a sound the student is getting out of their amplifier. And that's a big thing when you're playing a specific style of music,

> using the amp to get tone that's in keeping with the style of the song.

Teacher D was concerned about the reliability of the technology, explaining that they had achieved some limited success using videoconferencing on several occasions, but had failed on most attempts. They felt that the failure was due to poor broadband connection and latency, rather than the concept itself.

Concerns were expressed by all of the teachers except Teacher E about a possible social disconnect from students. Teacher B explained their own reservations:

> I think the problem with lessons over Skype is that you wouldn't have that personal connection that I think is so important to keeping folk engaged in the lesson. I think that's more something I need to get over, than it being an actual problem with the technology. I'm sure if I actually went ahead and did it, it would be totally fine, and I underestimate the students.

Some participants recognised that videoconferencing might be useful as a supplement to face-to-face lessons. Teacher A commented:

> I think Skype lessons have a place. I've done it mostly with students that have got an exam coming up and feel unsure in the last minute that they are capable, and I then suggest that we could have an extra Skype lesson.

Teacher B described students using videoconferencing to help each other in a collaborative learning environment which resonates with literature that advocates collaborative learning (Gaunt and Westerlund, 2013) and students learning from each other (Wenger et al., 2002):

> This year in the run up to the exams, I had a couple of students who actually had Skype tutorials with each other. They were practising pieces over Skype to each other in the week leading up to the exam […] they were encouraging each other, and it was mutually beneficial for them both, but it wasn't something I instigated, that

> was them […] it gave them someone else to ‘spar with’ in the run up to their practical exam which really helped them.

Teacher D was concerned about not being able to write on a student’s music using videoconferencing, which aligned with Duffy and Healey (2017) advocating for a shared digital score in the remote lesson. However, Teacher D was the only teacher in the study that suggested this, and they recognised that there were ways to overcome this, such as scanning an annotated copy of a piece of music and emailing it to a student or asking students to write in their own annotations during the lesson.

Teacher E described their own experience of being able to overcome the problem of physical disconnection:

> You shouldn't ever need to touch a pupil to move their arm and to put them in a certain position […] you teach them by demonstrating, and certainly if you're in a group teaching situation, you probably have one pupil who is doing it right, so you can get the others to refer to them, so there are ways around it. You've just got to think outside the box and think 'right, I need to do things slightly differently'.

> I've been videoconferencing teaching now for around 10 years and basically, every problem that I've had, I've been able to deal with remotely.

Teacher E also commented on a report from 2007 (Huddleston et al., 2007) into videoconferencing being used to provide tuition in schools in remote parts of Scotland:

> We did find that the pupils progressed the same, if not better, through the video link. The reason being pupils focus on it because it is new technology. So, it's something new, it's something cool, it's something different […] People have to be open to using technology […] but the lesson fundamentally has to have good content. If it's not got the content, it's not going to work whether you to have the most fancy equipment in front of you or not.

Having followed up this initial interview with Teacher E with lesson observations and a further interview (shown as E2 in Table 8), it transpired that the success of the remote lessons was more likely to be attributable to factors other than the technology being ‘new’ and ‘different’. Firstly, the teacher was enthusiastic, highly motivated, and had an excellent rapport with the students. Secondly, the teacher reported that the school communities were very supportive of the videoconferencing lessons. Staff would fetch younger students from lessons and accompany them to the videoconferencing room and help to ensure the equipment was set up correctly. The schools kept in regular communication with the teacher. Homework was sent via email to the schools to distribute to the students, adding another layer of accountability for the students as their class teachers were fully aware of what the students were supposed to be practising.

My view is that were this level of support put in place in schools where lessons took place face-to-face, lessons would likely be similarly successful. I agree with the teacher’s comments about the importance of good lesson content, and again, the teacher was highly organised with their teaching resources. The teacher was using the Polycom audiovisual streaming system which is more advanced than a standard videoconferencing system, and it also had an upgraded internet connection. Thus, the lessons had good audio and video quality, and in the four lessons I observed, there were no network dropouts.

### 4.2.6 Possible future developments

Teacher D expressed a desire for improved technology for videoconferencing, and greater reliability of the broadband connection. They also commented on the amount of new technology constantly being developed and the difficulty with keeping abreast of new developments: ‘Every time I have a discussion with somebody about technology, there’s a new app, a new thing’.

I discussed the concept of a Learning Management System (LMS) with participants, whereby a student could log in to record their practice and post

recordings. Teacher C commented: ‘That seems like the kind of thing that would be useful […] it might inspire them to practise a bit more’. Teacher C noted caution about parents contacting teachers between lessons via an LMS: ‘There would need to be some constraints there because I think it’s important to draw a line between life and work. I’ve even had parents that have Googled my name and found my mobile number from teaching websites’.

Teacher B described their own experience of using Massively Open Online Courses (MOOCs) as a learner and finding peer-to-peer assessment helpful. However, they also had some reservations about using online technologies, wanting them to be ‘robust and reliable’.

Teacher E discussed the problem of some schools and teachers not responding well to using technologies:

> I had a complaint from a school about SmartMusic, saying that they should be learning to read off the page instead of reading from SmartMusic because there is a cursor that can help you. But quite quickly, that teacher saw it demonstrated in a workshop by somebody else and said, 'well, actually, this is really good.' So, there are so many stumbling blocks to technology, and it tends to be older tutors, tutors who aren't experienced with it being scared of it, and schools that are a bit intimidated by it.

I asked participants whether they thought that videoconferencing could potentially replace face-to-face lessons. There were mixed views: Teacher A responded: ‘In videoconferencing lessons, I think basics could probably easily be covered, but I think advanced students would need to have a relationship with their teacher that is more than a TV screen’. Conversely, Teacher C felt that videoconferencing would not work well with younger or less experienced students but could work with older students for additional lessons, rather than replacing face-to-face lessons. However, Teacher E was enthusiastic about using videoconferencing with all levels of students:

> For me, face-to-face, videoconferencing, it makes no difference at all, and I think one of the benefits is, if the sessions can be recorded, the students can go back and see that and watch that and go 'actually, yes, this was right, that was wrong' and [...] it's just brilliant. For me, it's just as good, and in a lot of ways better.

The possibility of playing together with other musicians remotely was commented on by Teacher B. The stated that they would like the Internet and online technologies to develop to the point where it was possible to play with other musicians online in real time. This theme will be explored throughout the rest of this thesis.

## 4.3 Study 2: Survey of teachers and students experienced in the use of videoconferencing

### 4.3.1 Introduction

Following the initial phase of interviews, a larger set of interviews was conducted with 12 participants who had particular expertise of using videoconferencing for learning and teaching. For the purpose of this thesis, I define an ‘experienced’ teacher in videoconferencing as someone who, pre-pandemic, was regularly using videoconferencing for part, or all, of their teaching. Participants were selected through prior personal contact and availability, and I also posted on a university percussion teachers social media forum inviting teachers with experience of teaching via videoconferencing to participate.

These participants were: a cello teacher at a UK conservatoire who maintained contact with advanced students abroad via videoconferencing; a jazz guitar teacher based in Canada who had been using videoconferencing for private one-to-one students since 2011; a jazz piano teacher based in the UK; a university lecturer on a specialist music degree programme in the UK, delivered mostly by distance learning; two percussion teachers at universities in America; a lecturer on a teacher-training programme at a university in Brazil; a piping teacher at a HEI in Scotland; a postgraduate percussion student studying classical Indian tabla drumming; a postgraduate cello

student from America studying in Scotland, and a school string teacher in the UK. A list of participants is shown in Table 3 below.

The aims of this study were to understand:

- the rationale for using videoconferencing;
- what changed in the quality of the experience in lessons between face-to-face and videoconferencing environments;
- whether some elements of music instruction are more or less effective in these environments;
- the challenges that teachers experienced using videoconferencing, including technical, pedagogical, and social factors;
- how those challenges may be mitigated using current technology and with possible future technological developments.

The interviews were conducted between 2015 and 2021 via videoconferencing. The data includes excerpts from an interview in May 2021 with a string teacher working in schools to provide a fresh and up-to-date perspective of making the rapid transition to teaching online since the COVID-19 lockdown of March 2020.

| Participant | Instrument | Base country | Education setting |
|---|---|---|---|
| **E2** | Brass teacher | UK | Primary and secondary school |
| **F** | Cello teacher | UK | HEMI and private |
| **G** | Jazz guitar teacher | Canada | HEMI and private |
| **H** | Music lecturer | UK | HEMI |
| **I** | Jazz piano teacher | UK | Private |
| **J** | Piping teacher | UK | HEMI |
| **K** | Postgraduate cello student/teacher | UK | HEMI |
| **L** | Postgraduate percussion student | USA | HEMI and study in India |
| **M** | Percussion teacher | USA | HEMI |
| **N** | Percussion teacher | USA | HEMI |
| **O** | Music lecturer | Brazil | HEMI |
| **P** | String teacher | UK | Primary and secondary school |

*Table 3: List of participants in Study 2*

An example interview framework is attached at Appendix D. Similar to Study 1, the interviews were transcribed, coded, and analysed using template analysis. For Study 2, a mixture of coding was used: deductive coding to fit some a priori themes, such as the rationale for using videoconferencing, but also inductive coding, to allow new themes to emerge from the data.

The following themes emerged during the analysis:

- the rationale for using videoconferencing;
- technical quality;
- the learning and teaching environment;
- loss of physical presence;
- the importance of the visual element;
- change of teaching practice;
- the limitations of videoconferencing and authenticity of learning remotely;
- the importance of playing together in lessons;
- implications of using videoconferencing.

The terms ‘Skype’ and ‘Zoom’ appear in the interview data referring to videoconferencing. Whereas Skype was the most commonly used videoconferencing platform in 2015, by 2018, the Zoom platform was starting to become more widely used by instrumental music teachers.

The findings are reported below using the above headings, along with a separate section reporting the string teacher’s experience since March 2020.

### 4.3.2 The rationale for using videoconferencing

Various reasons were reported for using videoconferencing, including: increased accessibility; increased accountability; facilitating trial lessons, remote masterclasses, and supplementary activities. Additional reasons went beyond using videoconferencing for synchronous teaching, including: an improved teaching environment due to a reduction in noise levels, and additional functionality. These are outlined in greater detail below.

Videoconferencing was reported to afford greater accessibility to instruction. The music lecturer on the distance learning music degree programme (Lecturer H) reported that students were enthusiastic about videoconferencing lessons as it saved them the time and expense of long journeys to study with their teacher, and they reported a high level of satisfaction.

Student L described using videoconferencing to continue learning classical Indian tabla drumming after having face-to-face lessons with a local teacher, and then moving to a different location and not being able to find a teacher for face-to-face lessons: ‘Skype was kind of a game-changer for me because of this amazing teacher who lived in a different country, but we were able to meet regularly via the Internet’. This student subsequently travelled to India to study tabla more intensively in an immersive environment and this will be discussed in Section 4.3.8.

Teacher M described how videoconferencing was used to facilitate remote percussion masterclasses at a university in the US. Having the remote masterclasses afforded students access to a greater range of visiting teachers, but also gave teachers an opportunity to learn from watching other teachers:

> It was a success for me watching these amazing players and educators teach a masterclass. How they did it, what they said, and what they focussed in on. What their angle was of how they approach teaching what they thought was important, and what they thought wasn't important, the whole experience of watching.

The piping teacher (Teacher J) discussed the importance of having a regular lesson and how using videoconferencing increased access to specialist lessons for international students:

> The e-learning portal and Skype are an aid for people that aren't able to access face-to-face tuition on a regular basis. Some will almost never get face-to-face lessons; others use it to supplement what they already get. This morning I gave a lesson to a young lad in the Falklands who gets no tuition at home in the Falklands at all. All he has learnt has been via one-to-one lessons on Skype. I know

> for some students it is a lifeline and they rely on it, even if it's just having the pressure of a regular lesson […] my two longest-serving students are Skype students […] I think they just need the regular interaction as a sort of motivator.

Student K described how videoconferencing was used to facilitate a trial lesson between their institution in America and an institution in Scotland to help in deciding where to study abroad: ‘That was a nice way to try out who I'd be studying with over there once I decided that I maybe wanted to go and do that’. However, there were some logistical challenges in setting up the trial lesson. The student’s home university had a dedicated videoconferencing suite using studio-quality microphones and multiple cameras which required the assistance of technicians. The student therefore had to coordinate not just their own schedule and their teacher’s schedule with the teacher in the other institution, but also the technicians in both institutions, as well as considering international time differences, and it took over a month to arrange. Thus, despite the apparent convenience of using videoconferencing, there can be challenges when arranging multiple participants.

Teacher M discussed the possibility of augmenting regular face-to-face lessons with a principal teacher with supplementary lessons from a different teacher via videoconferencing:

> I think the perfect situation would be a teacher that was open minded; you’re with them on a regular basis face-to-face, but if I wanted to take a lesson with Peter Erskine [session drummer] for example, it's expensive to fly to LA, to get a hotel, to pay for a lesson, to have my meals there. It would be much easier, and I could possibly do so more often, to just call Peter up […] and that way you're getting the best of everything.

Teacher N reported using videoconferencing in conjunction with the Blackboard platform to teach an online music degree course including aural skills, theory, orchestration, private composition lessons and some percussion lessons, and they reported success with all these different areas.

In addition to convenience and increased accessibility, there are other advantages to videoconferencing. The jazz piano teacher (Teacher J) discussed using overhead cameras as well as MIDI keyboards in videoconferencing lessons to allow students to easily see exactly which notes are being played and which fingerings are used:

> We've got all these other tools: the on-screen share, you can see exactly what's happening with my hands. In central London, I've got two grand pianos in the same room, but students don't come over and look, whereas here, it's just so visual.

Teacher I also discussed using the Zoom platform to record portions of lessons to share with the student for review between lessons. As reported in the previous study, this is also possible in the face-to-face lesson, but it is easier in the videoconferencing lesson as all the equipment is already in place, and there is therefore less disruption to the flow of the lesson.

Teacher E2 reported that an additional benefit to using videoconferencing was a noticeable reduction in noise intensity during the videoconferencing lesson due to students being located in a different studio. Shepheard et al. (2021) report that repeated exposure to high sound pressure levels in relatively small practice rooms can cause noise induced hearing loss.

If their teacher is touring, students are potentially able to continue their lessons via videoconferencing. However, a teacher at a UK university reported to me in 2019 that some years previously, they had been using videoconferencing to maintain contact with students while on tour. Following complaints from colleagues who were apparently anxious about this development, the teacher was asked by their head of department to discontinue teaching via videoconferencing.

Teacher G explained how at the time of the interview in 2016, there was resistance to using videoconferencing technologies at some universities in the US:

> I go into to talk to department chairs, or deans, and they look at me like it's from outer space and not anywhere near their realm of possibility, and they're just shocked that this is what I do. They're like, 'what do you mean you teach on video?', it's just not part of their language. But that will change over time.

Thus, attitudes to technology can determine whether it is accepted or not in institutions (Brudvik, 2018). The above examples demonstrate that prior to the pandemic, the use of videoconferencing was not universally accepted and was even met with some scepticism and opposition.

### 4.3.3 Technical quality

The experience of using the hardware and software in videoconferencing ranged from general satisfaction with the audio quality of internal speakers and microphones found on a standard PC laptop or MacBook, through to a preference for using external high-quality microphones and headphones to improve audio quality.

Student L commented on the built-in microphone and speakers on a laptop computer being mostly adequate: 'The audio quality was decent. I mean there are certainly things you lose in terms of tone quality of the instrument unless you have a really good sound system setup, but I was just using my computer'. However, Teacher F commented: 'My biggest concern is really the sound quality. I mean it's good, it's reliable, but it's not as nuanced as I would like'. Lecturer O commented that when they started teaching online, their institution only had basic microphones. This resulted in students being unable to differentiate between different types of sounds when the teachers were demonstrating different playing techniques. Thus, having high-quality audio is important to the overall feeling of satisfaction.

Student K discussed improved audio and video quality from a dedicated videoconferencing room at their university with technical support:

> I do remember being surprised at how good quality the audio and video were, especially when I sat down in the videoconferencing

> room in the US. We didn't immediately start the lesson; I also had a sound check which was really useful as I was able to hear that audio first-hand. There were a couple of mics, one placed right above me and one placed a bit closer to my bridge, so I was able to play the first couple of lines before connecting with the teacher and then hear that back. That was actually really helpful to get a sense of what he was going to hear because I wanted to give a good impression.

However, as discussed in the previous section, more advanced technical setups may require technical assistance which can complicate trying to coordinate remote parties, and depending on the type of situation, a basic setup using built-in microphone and speakers may be sufficient.

Bigger screens improved the experience, as reported by Teachers F and H. However, other teachers felt a bigger screen was unnecessary, and that 'cheap and simple works best' (Teacher G). There were also mixed views on having multiple camera angles. Some teachers considered this important, while others thought that this may be unnecessarily complicated.

Teacher N commented on how much of a difference the interrelated factors of the quality of hardware combined with type of videoconferencing platform and the quality of the network connection can make in a lesson. Teacher N also commented on the importance of sound quality for teaching percussion lessons remotely, and how pre-recording resources, or using other asynchronous resources can assist students to hear timbral changes that may not come out so clearly over a videoconferencing connection:

> The sound is never going to be the exact same, so if we're working on timpani, I'll have to back away, otherwise the microphone can't take it. So, I try to say, 'I want you to make this sound versus this sound'. That usually doesn't transfer as much as being there in the room […] What I found would work is, 'OK, let me make a video'. I can use my cell phone because the camera and video quality are really good. I can make small videos of 'alright, here's the timpani, here's what it sounds like close to the edge, versus playing here', so I can duplicate that, and then upload those snippets into files and send that to the student, and say, 'view those 15 seconds versus this'. So, I can have some sort of prep videos to do with it. I think that works really, really well.

Thus, asynchronous resources can be successfully used in combination with videoconferencing to enhance the student experience. However, this takes additional time for teachers to prepare, but once prepared, they can be reused.

### 4.3.4 The learning and teaching environment

The quality of the studio environment is important in face-to-face teaching (Hallam, 1998) and also in remote lessons. The remote environment is affected not only by the physical studio environments of both locations, but also by other factors including the quality of the audio and video equipment; the placement of the camera, screen, microphone and speaker/headphone; the quality and stability of the network connections; and the presence of other parties such as studio technicians.

Participants reported that it initially took time ranging from several minutes to several individual sessions to become accustomed to the videoconferencing environment. Some attributed this to not being able to trust the intuition that comes from being in the room together with their students and missing the 'sense of presence'.

Teachers and students were also apprehensive about using the technology for the first time. Teacher N stated:

> When I first started teaching like this, I was nervous, and it was really difficult, because you're not in the room […] but now it's fine. I think with experience, we can get through it, and get a really good lesson and a learning experience out of it.

Student K commented on feeling slightly anxious at having an array of microphones in the studio for their trial lesson:

> I had recorded in a studio by that point, so I was comfortable to an extent with microphones being placed around me, but I guess it was also a bit nerve-wracking. It did feel a bit technical, like 'oh my gosh, all of these mics around me, this is real', but at the same time it's

> nice to know that these mics serve to improve the quality of my sound which will allow this to go better, so it was definitely a mixture of feelings there.

Student K also commented about initially feeling uncomfortable with having technicians present: 'it was a bit uncomfortable just knowing that they could hear everything, but that did kind of go away after a while'. They went on to comment that it was also reassuring to know that they were not solely responsible for the technical aspects, and having overcome their initial apprehension, they found the presence of technicians helpful and supportive in setting up microphones and switching cameras angles.

Thus, a variety of factors contribute to the level of comfort for teachers and students in the videoconferencing environment, but participants generally felt that with more experience, it became easier.

### 4.3.5 The loss of physical presence

Participants commented on the loss of physical presence being an issue, including not being able to physically adjust a student's posture, or adjust or repair instruments. Teacher J discussed the loss of physical presence when teaching pipes, and the importance of setting up the instrument, and demonstrating how to hold the instrument:

> Limitation wise, there are several. First one in terms of teaching the pipes is the actual handling of the instrument itself. One of the major issues that most people have until you get to a relatively advanced stage in piping is maintaining and tuning of the instrument, tuning particularly […] There are four reeds in a set of pipes, you need to adjust each of those reeds to suit each individual. […] Every reed is individual and to an extent, every instrument is individual as well, so it involves actually setting the instrument up for the individual. So, doing that and also just demonstrating how to hold the instrument, how to efficiently get the instrument up, and how to efficiently maintain a tone through it is something that can only really be done with a hands-on approach.

Teacher M also commented on not being able to physically adjust a percussion student's grip, or adjust posture:

> … you can't reach out and touch the person that you're working with, you can't grab their hand to help them make a stroke. Or sometimes you just walk up to a student and touch his shoulder to make them relax if they get a little bit tight.

However, Teacher F also commented on adjusting posture and diagnosing physical problems:

> If it is a student that I haven't met face-to-face and worked with, if it looked like there was tension in the upper arm, it could be caused by shoulder tension, back tension, thumb tension all sorts of things […] and I think it would be very difficult to diagnose that over the Internet.

Early diagnosis of physical problems by a teacher is essential for a student's long-term health. According to Betzl et al. (2020), prevention of physical problems is key, as undiagnosed postural problems can lead to long-term conditions for musicians which can cause debilitating pain and may require surgery.

Teachers experienced in the use of videoconferencing developed a range of strategies for guiding students in carrying out simple instrumental adjustments or repairs remotely, which included asking students in a group teaching setting to assist others (Teacher E) or referring students to online instructional videos (Teacher G).

Teacher J used metaphor and imagery to assist students when trying to describe a particular technique. Schippers describes a teacher of Indian classical music in a face-to-face setting instructing students to play "as if there is a small bird sitting on your finger, and you don't want it to fly away" (Schippers, 2006, p.211), to improve the subtlety of their tone quality. Given that many schools already adopt a 'no-touch' policy, teachers should already be used to finding alternatives to physically adjusting students' posture in the

face-to-face environment, and metaphor and imagery should therefore easily translate to the virtual environment.

The problem of not being able to ‘read the room’ in the virtual masterclass environment was discussed by Teacher M:

> You can't read the viewers. Every once in a while, when we would have a masterclass, I'd take the big camera and just kind of pan around the audience so that the guest could see that there were people and get a little bit of a read on whether half of them were sleeping or what the interest level was.

The extent to which problems can or cannot be dealt with remotely may be instrument-specific, as with the example of the pipes. Participants discussed how these problems can be mitigated by the use of asynchronous resources such as videos demonstrating simple repairs or adjustments. However, some problems will also be student specific, and postural problems can eventually lead to chronic conditions. Thus, consideration needs to be given to early diagnosis of postural problems. Here, the sharing of good practice among teachers in different instrument categories would be an important step in helping to prevent injuries caused through overuse and poor posture.

### 4.3.6 The importance of the visual element

Of the two elements in videoconferencing: audio and video, audio was considered the most important, and in situations where network connections were particularly poor, participants would reconnect using audio only. Teacher J commented:

> All I need is the audio really. Sometimes you will find if it's a particularly bad connection, I'll often just ask the student to turn off the video and I'll do the same which improves the audio. As an experienced teacher, I can trust my ear enough. So, you can get by without the video, but the thing you lose is the human interaction level, just being able to see someone. But it is OK as long as you've got an established relationship with the student.

The importance of audio was further iterated by Teacher G:

> Doing it this way has trained me to hear differently from a teaching perspective. I can't always rely quickly on visual, and if it's a long melody and the student's hand happens to slip down and I can't see it, I don't want to ask them to replay the entire melody. I've just got used to hearing what I should be seeing.

However, wherever possible, video was used as the visual element was considered important for communicating gestures and seeing facial reactions in checking students had understood concepts. Teacher I reported:

> I realise how valuable a face can be. So, I'll often get a student ask, 'do you want my camera over my keys, or do you want to see me?'. I always go for the face, because I can virtually always hear what they're playing. I'd much rather see their reaction; I've realised how important reactions are for my teaching.

Teacher M also discussed the importance of the video element:

> 'It is absolutely critical because I think people saw things that they could comment on that they might not have been able to hear […] If you know the instrument, you can tell a lot about what's happening by just viewing the stroke […] you can perceive quite a bit about the tonal quality'.

Thus, where either the audio or the visual element was poor due to technical problems, experienced teachers would compensate by relying more on the other element. There is a risk that without the visual element, teachers may not be able to diagnose physical problems with students, and the importance of the video element will also be discussed with regard to low-latency technologies in Chapter 8, Section 8.5.2.

### 4.3.7 Change of teaching practice

The participants discussed changes of their teaching practices. All the participants reported that the videoconferencing experience was more intense

and more tiring for them, and required extra time commitment and preparation of resources. Teacher F commented:

> I think it's a lot more work for the teacher. I mean, I spend way more hours than I get paid for. There is an expectation that they need a bit of extra support because of the distance.

The importance of preparation in setting up the percussion studio was discussed by Teacher N, whether sending media files in advance, or bringing in another student to the teacher's studio so they could demonstrate different technical or postural changes: 'There are ways around anything, as long as you pre-plan. To me, this is no different than teaching a class, it's just in a different environment.'

The use of 'on-demand' asynchronous resources were discussed by Teacher J:

> You're never going to schedule things for a suitable time for someone on the east coast of the States, New Zealand, and South Africa all at the same time. People are interacting with it more in an on-demand way, so they'll take out a subscription and access stuff on demand when it suits them, which is good as well for us, not trying to bend over backwards trying to accommodate different time zones.

A problem experienced by teachers making pre-recorded videos was a feeling of needing to eliminate stumbles or mistakes when speaking, which greatly increased the time spent on producing resources.

The problems of using asynchronous recordings for assessment, and the problems of 'massification' were discussed by Lecturer O, with there being expectations of teachers assessing greater numbers of students. Teachers had previously been encouraged to record video feedback for students demonstrating technical aspects, but it was becoming more difficult due to ever increasing demands on their time.

Videoconferencing was reported to be more efficient and productive than face-to-face lessons. Teacher G commented:

> I find Skype lessons are much more efficient […] here, I can tell you to improvise over a track, and while you're improvising, I can go 'oh ok' and write myself a little note pretty quick, and then go back to listening. Even for take-home notes, I can be talking to you and typing pretty quickly while I talk. Whereas in person, I have to stop and take a piece of paper off the stand and write, and during that time the student is just kind of sitting there. To be able to have the perspective, almost of an audience member, I can really hear what an audience can hear, and I can home in on those kind of things.

Teacher G also commented on not having wasted time with setting up, as both student and teacher can be set up in their respective studios and ready to play: 'you sacrifice a bit of the social aspect, but I get much more done in an hour on Skype with a student than I would in person. So, there are trade-offs'.

Teacher I also identified similar productivity when they commented:

> I think a Zoom lesson can be more productive. We seem to get down to work much quicker with most people. I have a student who always likes to talk to me for a good 25 minutes if not longer in an hour's [face-to-face] lesson, but I don't think he would do that if it was on Zoom. I think you can be very productive because it feels more like a meeting.

However, Teacher F did not note much difference between face-to-face and videoconferencing lessons:

> I thought in a lot of ways, it felt similar as a lesson in person. We spoke about a lot of topics we would have talked about in person, I feel that we pretty much had the same contact as in a face-to-face lesson.

Clearly, every teacher-student dyad will have a different social dynamic, but the experienced videoconferencing teachers agreed that lessons were generally more productive for students via videoconferencing.

### 4.3.8 Limitations of videoconferencing and authenticity of learning remotely

Various limitations of teaching via videoconferencing were discussed in addition to loss of physical presence, including missing out on cultural elements and authenticity of playing and learning when studying remotely. Instruments such as pipes were reported as being difficult to teach in the online environment, suggesting that remote lessons do not give the full experience that a face-to-face lesson brings.

Student L started off learning tabla face-to-face with a teacher in USA, then continued their studies via videoconferencing with a teacher in Canada before moving to India to learn with a guru. The participant described their experience of completely immersing themselves in the culture and traditions surrounding the instrument while studying in India. Longer sections of the interview transcript are included as I feel that by paraphrasing, the impact of the participant's words would be lost.

> I used Skype for about two years before I finally moved to India to study the tabla more intensively. It was then that I realised in hindsight how much I lost from videoconferencing, because now I had the experience of playing in person, and at the same time, with somebody every single day. I would be able to hear the teacher and see the teacher's hands right in front of me as I'm playing.
>
> I found that living in the environment and being fully immersed in the culture of the instrument I was studying was a crucial element of learning that I didn't get from Skype. While in India, I met with my teacher six days a week for about two hours each day. And in this tradition, we would play short exercises or musical phrases together, sometimes for about 30 minutes before moving on to the next one. We would spend quite a bit of time just repeating the same thing over and over again, to work on tone quality and speed, and overall playing stamina, which dramatically improved my playing technique.
>
> Because this is learned through an oral tradition, it's spoken to me, I memorise it. You can write it down quickly in your notebook, but largely you're memorising it on the spot and repeating it back. Then I would go home and practise that repertoire and those techniques

> that I learned and come back the next day and learn something completely new. So, it's actually a lot different to how I learned Western musical instruments. In the West, my experiences have been that you go for a lesson, an hour long or something, you play for your teacher and then they'll make comments. Rarely though would the teacher play with me, to this degree anyway. It's just a different system. So, this is the main element missing from videoconferencing. It's just not possible to replicate this type of experience with the limits of internet connection and digital sound quality.
>
> Even though a lot of it is about the lesson in the room with the teacher, so much of the lessons are also about experiencing the culture outside of the studio too: going to live performances with tabla and Indian instruments; observing how the instruments are built; and watching how other people practise and perform. So, it's not all about just what happens in that time frame of a lesson, whereas with videoconferencing, really all you get is just that structured time. Oftentimes, I would go to my teacher's house, and I was able to catch a little bit of the lesson happening before mine, or maybe it was a rehearsal with instruments and dance.

This raises questions of authenticity in playing, and also fundamental differences between different approaches to learning (e.g. the Suzuki method), and how well these different methods transfer to the remote learning environment. In the example above, the tabla student clearly felt that it was essential for them to have face-to-face lessons in order to assimilate different cultural elements that went with the tradition. However, the student also reported making progress with a teacher via videoconferencing following their initial set of lessons. Furthermore, travelling abroad to study with a teacher shows a high level of commitment to learning which may be beyond many students.

### 4.3.9 The importance of playing together in lessons

Teachers reported not being able to play together with students in videoconferencing lessons due to issues of latency and software as a problem. Teacher F remarked on their frustration at not being able to play with or accompany cello students during the lesson; Student K discussed the

importance from a teacher's perspective of playing together when learning tunes in Scottish traditional music, and how this changed in the videoconferencing lesson:

> It feels very different, just because in trad, especially when you're trying to teach a tune aurally, it helps to play the tune with the student. Or if you're trying to communicate a sense of groove, or a dance-like rhythm, it helps to play it together. I have found it is really best communicated by playing with the students so they can actually experience it. It just has made the most sense in person. And so, without being able to do that, that's kind of a challenge to try to work around and achieve a similar result. A way around that has been to send recordings that they can then play with […] when you're first learning a tune, you're not playing together yet, but once you're really trying to get the hang of it that then becomes a lot easier to play in person at that point.

The importance of having a teacher physically present to conduct or sing while the student performs a slow melody on the pipes was discussed by Teacher J:

> The 'pibroch' style of music is not to any form of strict metre, and essentially the tradition has been passed down aurally. My experience of having been taught it as a youngster, and even to this day, is that it relies to an extent on a degree of conducting by the teacher to demonstrate. Although we can't swell notes in the way you would on a violin, it has implied dynamics in the melodic flow, and that's what you would want to try and put across to a student through the conducting style that I would adopt. That, and singing along with them as they're playing, which obviously with any form of time lag on Skype just doesn't work at all.

Some teachers had developed strategies for overcoming the problem of not being able to play together with students in lessons. Teachers E and G had developed similar strategies to Student K, by asking students to play along to backing tracks and accompaniment software such as iReal Pro. Teacher G commented:

> The only thing missing in Skype lessons is jamming together, though that's more a software issue than latency. When one person

> talks it makes the other quieter. Broadband is now getting into fibre optic, almost the speed of light, so it's fast […] but the software doesn't allow you to jam. I have seen some people try and do that with jam software, but I've never seen it work. So, I think that's going to be the next step, someone will come up with Skype for musicians, or Skype will figure out, 'OK we have to solve that issue somehow'.

Teacher G went on to state that they actually preferred not playing together with students during lessons:

> That's the only difference, and to be honest, I prefer it. Not that I don't like to play with my students, but when you're playing, I can be really paying attention and taking notes, but if we're jamming together, there's still a part of my brain that's thinking what the chord change is. I've actually noticed that my note taking is much more detailed. I hone in on things that I wouldn't home in on necessarily if we were jamming together, just because I would be thinking about my playing and it would be distracting. It's not a huge deal, but it's a little different and I think that actually helps.

It was an unexpected finding to have two teachers state that they were not concerned about the loss of being able to play together with students. As reported in the preceding text, Teacher E and Teacher G had devised strategies over several years of teaching via videoconferencing allowing students to play in time to backing tracks. For other teachers with less experience, or in different instrumental disciplines such as piping (Teacher J), not being able to play together with students in the videoconferencing lesson remained an impediment.

### 4.3.10 Implications of using videoconferencing

Participants discussed the evolution of the technology, and the implications this would have on learning and teaching in the future. Teacher F sounded a note of caution about the adoption of videoconferencing over face-to-face teaching:

> I've been talking to a conservatoire about this in terms of increasing their distance learning over the summer, and saying I just think they need to be very careful that it doesn't become something that is any

> more than enhancing what's already available, that it doesn't become an alternative. I think that could be really difficult for string teachers, or string players […] It is definitely limited.

Students learning remotely should also be exposed to a full range of rehearsal and performing experiences with other musicians, as reported by Teacher F. However, this interview was conducted pre-pandemic, and videoconferencing and the use of asynchronous resources have since become important tools for music teaching during lockdowns where face-to-face interactions were largely prohibited.

The piping teacher also felt that videoconferencing lessons could not adequately replace the experience of face-to-face lessons:

> I can't see a situation where it will ever supplant face-to-face. You can probably just about get by learning the basics of the practice chanter on Skype, it would very much depend on the individual though […] But then making the transition onto pipes, it's honestly completely impossible to do unless you've got someone there to manage the instrument for you straight away, because of the physicality of the instrument […] trying to do that without face-to-face guidance is not going to happen!

Despite these earlier reservations from some teachers, Teacher G and Teacher I have built successful online studios teaching jazz guitar and jazz piano students worldwide, and for them, videoconferencing lessons are a success. Teacher G discussed how even before COVID-19, videoconferencing was becoming more widely used:

> We grew up in an era where you used to play with people. If you went for a lesson, you played with your teacher. But for anyone under 20, that might not be the case, such as playing with backing tracks, or learning from YouTube, or Skyping their friends, or taking Skype lessons. I teach people from all over the world, and for some of them, this might be one of their first experiences of not just a Skype lesson, but a music lesson, ever. So, for them, this is it, there's no other way of doing it. I think in the next 10 years, most people are going to forget what that was like.

The use of videoconferencing has implications for changes in the instrumental teaching workforce. Institutions can potentially hire teachers from anywhere in the world. Teacher G discussed implications for hiring staff at universities:

> You can just pay someone an hourly rate in New York to teach your students via Skype lessons. You don't have to worry about hiring someone, it saves having to fly them in, or get them to drive in and their driving fees, it actually cuts the costs down. Plus, students can study with named teachers or experienced teachers in New York.

All teachers stated that they would welcome improvements in the technology that would allow for faster and more reliable connections. My earlier experiences of videoconferencing from 2010 to 2017 were dogged by technical problems. By comparison, I have noticed a marked improvement in the quality and stability of videoconferencing platforms since 2018, particularly since switching to the Zoom platform.

The following interview was conducted in May 2021 and gives an up-to-date account of a string teacher's response to teaching via videoconferencing following the COVID-19 lockdown.

### 4.3.11 A string teacher's experience of online teaching since the COVID-19 lockdown of March 2020

I discussed the rapid transition to teaching online with a string teacher (Teacher P) working in schools in Scotland in May 2021. They taught a range of younger students from aged 7 to 15, from beginner standard up to grade 8 ABRSM. They experienced similar problems as reported in the previous findings, including technological challenges due to poor internet connection and sound quality. They also reported additional problems caused by the pandemic, particularly regarding student wellbeing.

They noted difficulties with explaining posture remotely, especially with younger and less experienced players: 'In technical matters, there were a lot of bizarre postural things that cropped up. Then there would have to be a continuous reminder all the time, and that wouldn't have happened I don't

think, in person'. They also noted difficulties with tuning instruments, and made instructional videos for parents on how to tune and maintain instruments.

They reported some students being much more creative and collaborative in the online setting:

> Some of the students did really interesting things. We worked on how you can use your classical training to play a pop arrangement of something that they wanted to do, and they worked on collaborating with each other in some ways, which is really interesting. And I think a lot of them were fairly driven to keep it up so they wouldn't be behind when they came back. So, a lot of them actually came back way better than I thought they would be and have progressed really well.

However, some students did not cope well during the pandemic, with the students and parents not responding to emails. This was attributed more to stress and overwhelm with all their school activities being online, than because of the string lessons being online, per se.

Teacher P's teaching style changed in the videoconferencing setting and they used the lesson time differently than in face-to-face settings:

> I had to address our time very differently. So, I only have 45 minutes for the group lesson with up to five players, so I'd have to be looking at their technique and going through them individually throughout the lesson, but also trying to get them engaged with each other […] to be honest, the classes were totally different, they're just completely tossed on their head.

Teacher P adapted how they taught as they became more experienced at working in the online environment:

> They all love being together, they get to play with each other, and they get to hear and interact with how others play and give feedback. So, making sure that they felt like they're engaging with each other more, I think I could have done that better at the beginning […] Basically, I just had to be much more prepared before

> their classes […] because otherwise you'd waste half your lesson trying to put in bowing markings into an eight-year-old's music via Zoom.

However, there were some elements of teaching online they would like to retain in the future:

> The ability to create videos with their friends; we did some distance recording for them to get used to how you do that, I think those are really nice things that we should get used to. As musicians, I can't tell you how many times I myself have had to record things distantly […] I think the biggest thing would be having far more collaboration, it allows you to be far more creative and explorative in the music.

Teacher P noted that this is an opportunity to change how musicians are taught, and to break away from some of the more established traditions of music education:

> What people are expecting from us as musicians is changing so much; this pandemic has definitely shown that, in the fact that we need to start doing more unusual things, more collaborative things, more things that can be shared online, more things that are just a little bit more engaging for the public, and kind of bringing in a new audience.

> It has made us as teachers be much more adaptive and have to totally restructure everything […] I think there are great things about having online lessons, especially accessibility when you're not able to be there […] I think it's just all putting us in the direction of noticing that things need to be altered, and we can incorporate some of these things going forward. We've learned from that.

Many of the points discussed by the string teacher echoed findings from teachers in earlier interviews prior to the COVID-19 lockdown. The teacher also noted that students had missed playing together in real time, hence the teacher's encouragement of students collaborating on joint recordings, and the teacher wanted to retain this element of collaborative work with students in the future.

## 4.4 Study 3: An investigation into the frequency with which teachers and students perform together in face-to-face instrumental music lessons

### 4.4.1 Introduction

The findings of Study 1 and Study 2 revealed that many teachers were frustrated at not being able to play together with students in the videoconferencing environment. Based partly on these studies and my own experience as a musician and teacher, my view was that playing together formed an important part of face-to-face lessons, and that being able to overcome this would be a significant improvement in instrumental music lessons delivered by remote learning. A literature search supported this view (Hallam, 1998; Ley, 2004; Mills, 2007; Rife et al., 2001), but did not reveal any empirical studies.

The aim of Study 3 was to investigate the frequency with which teachers and students played together in co-present face-to-face instrumental music lessons across several disciplines. Data were collected from a total of 29 instrumental lessons given by individual teachers of percussion, guitar, strings, and two brass teachers. Participants were selected for convenience and their ready availability (Waterfield, 2018). A previous study by Dye (2016) analysed teacher and student behaviours in music lessons using an observational tool adapted from Siebenaler (1997) in which specific observable behaviours were recorded; these included the teacher demonstrating on their instrument, the teacher giving a general non-specific instruction, and the teacher asking a question. I considered this to be a suitable method of data collection with appropriate modifications to suit this study.

Specific observable behaviours were first defined: teacher demonstration, teacher and student playing the same part simultaneously, student playing with accompaniment from the teacher, student playing with a recorded accompaniment. A handheld whiteboard and marker was chosen as a reliable

method (Yarbrough, 1992, p.90) for counting behaviours during the lesson; results were then tallied up and tabulated. A total of 25 face-to-face individual and group lessons were observed in primary and secondary schools, with a range of student ages from 10–16 years old. Primary school students in their last year of school (P7) were aged 10–11; secondary school students in their first year (S1) were aged 11–12, and so on, up to S5 aged 15–16. Each lesson lasted between 25 and 35 minutes. Data were also collected from observing four lessons conducted by a brass teacher (Teacher E from previous studies) using videoconferencing. However, only general observations were noted as, owing to the limitations of the Polycom technology, the teacher was unable to perform synchronously with the students.

Colwell (2011, p.95) describes a model of 'direct instruction', sometimes called 'explicit teaching' or 'systematic instruction', in which instruction is grouped into six teaching functions: daily review, presenting new material, guided student practice, feedback, independent practice and/or homework, and longer-term review. The teaching interventions observed in this study related to four of these functions.

Four separate types of interventions were logged as events:

- teacher demonstration: presenting new material or reviewing previously covered material;
- teacher and student playing the same part simultaneously on the same type of instrument, i.e., strings teacher playing violin at the same time as the violin student: feedback and guided student practice;
- student playing with piano or guitar accompaniment from the teacher: feedback and guided student practice;
- student playing with a recorded accompaniment: feedback and guided student practice.

An event was counted as an uninterrupted sequence of playing, from just a few bars, up to a full study or piece. A fifth type of event observed was that of the student playing on their own. However, this occurred so frequently in each lesson that it was not logged. I considered another method for data collection, that of recording percentage of time spent on each activity. This was discounted as the process would have required recording lessons, which I felt may have altered teacher and student behaviour, or sitting with a stopwatch, which I felt would have been distracting.

### 4.4.2 Findings

The findings from the face-to-face lessons showed a range of teaching strategies used in relation to the following factors:

- number of students in the group;
- the age, stage and experience of the students;
- the type and availability of instruments used, e.g., percussion lessons, where students may have to take turns of using larger instruments such as timpani or marimba;
- the stage in the learning cycle, from completely new material to familiar material being reviewed in preparation for a performing exam;
- the type of repertoire used.

The full results are shown in Table 4 below, with each number representing a specific observed strategy. The total results from the 25 lessons were as follows:

Teacher and student playing together: (*n* = 153)
Teacher demonstration: (*n* = 151)
Student playing to teacher accompaniment: (*n* = 78)
Student playing to recorded accompaniment: (*n* = 66)

A typical lesson observed was that of lesson 13, where an S1 student (11 years old) was being taught a new piece with a pre-recorded backing track for drum kit. Two drum kits were available in the studio, allowing the teacher to play at the same time as the student. The whole piece was first demonstrated by the teacher along with the backing track. The structure of the piece and different elements were then briefly discussed (Function 2, presenting new material).

The teacher then demonstrated each small section of the piece, immediately followed by asking the student if they had understood it or required further demonstration or clarification. The student was then asked to play along with the teacher as many times as necessary until the teacher was satisfied the student was able to play the section, before the student played the section on their own to check their understanding (Function 3, guided student practice).

| | | | Number of occurrences per lesson | | | |
|---|---|---|---|---|---|---|
| **Lesson number** | **Class** | **Instrument** | **Demonstration** | **Accompaniment** | **Playing together** | **Playing to recording** |
| 1 | S1 group | Percussion | 8 | 1 | 12 | 0 |
| 2 | S1 | Guitar | 11 | 0 | 2 | 0 |
| 3 | S3 | Strings | 2 | 4 | 7 | 0 |
| 4 | S1 group | Percussion | 9 | 0 | 12 | 0 |
| 5 | S1 group | Drum kit | 6 | 0 | 1 | 0 |
| 6 | S1 | Brass | 7 | 4 | 8 | 0 |
| 7 | S1 group | Guitar | 7 | 2 | 8 | 0 |
| 8 | S2 group | Guitar | 4 | 6 | 4 | 0 |
| 9 | S4 | Brass | 2 | 0 | 0 | 3 |
| 10 | S1 | Strings | 4 | 0 | 16 | 0 |
| 11 | S1 group | Brass | 9 | 0 | 0 | 0 |
| 12 | S1 group | Percussion | 12 | 7 | 6 | 0 |
| 13 | S1 | Drum kit | 16 | 0 | 9 | 3 |
| 14 | S5 | Percussion | 5 | 0 | 0 | 5 |
| 15 | S4 | Drum kit | 8 | 0 | 22 | 22 |
| 16 | S3 | Strings | 1 | 6 | 3 | 0 |
| 17 | S4 & S5 | Brass | 1 | 8 | 0 | 0 |
| 18 | S1 group | Drum kit | 2 | 0 | 2 | 15 |
| 19 | S1 group | Drum kit | 2 | 0 | 0 | 17 |
| 20 | S3 | Guitar | 8 | 4 | 12 | 0 |
| 21 | S2 | Brass | 10 | 7 | 10 | 0 |
| 22 | S1 group | Strings | 4 | 0 | 3 | 0 |
| 23 | S3 | Strings | 3 | 10 | 0 | 1 |
| 24 | P7 group | Brass | 5 | 6 | 8 | 0 |
| 25 | S3 group | Guitar | 5 | 13 | 8 | 0 |
| | | **Totals** | **151** | **78** | **153** | **66** |

*Table 4: Summary of findings from Study 3*

Two larger sections of the piece were then practised along with the teacher and the backing track together. Feedback was given to the student about particular points to work on (Function 4), and the student was then asked to practise at home (Function 5) for the lesson the following week. The events observed for this lesson were as follows: demonstration (*n* = 16); playing together (*n* = 9); playing to pre-recorded backing track (*n* = 3).

The highest instance of teacher and student playing together occurred 22 times in lesson 15: an S4 student preparing a drum kit piece for a performing exam. The student had recently joined the school and had a limited amount of time (several weeks) to learn new repertoire for a performing exam. Following daily review (Function 1), the student was found to be struggling to play a 'shuffle' rhythm in time to the pre-recorded backing track. The teacher loaded the backing track into the Speedshifter app (a piece of software that allows the tempo of a recording to be altered without changing the pitch) and adjusted the tempo to half that of the original tempo (Function 2). The student struggled to play along to the backing track even at the slowest tempo, so both student and teacher played simultaneously on two separate drum kits along to the backing track, gradually increasing the tempo until the student was able to play at the full tempo of 108 bpm (Function 3, guided student practice).

This example evidences a form of scaffolding for the student. Wood et al. (1976, p. 90) define scaffolding as: 'those elements of the task that are initially beyond the learner's capacity, thus permitting him to concentrate upon and complete only those elements that are within his range of competence'. By the end of the lesson, the student was able to play the rhythmic style along to the backing track at the full tempo with some success, though there were stumbles. The student was given feedback (Function 4) on specific practice strategies for independent practice between lessons (Function 5).

During the four brass lessons delivered via videoconferencing, despite the teacher not being able to perform synchronously with the students, the students learning in pairs or groups were able to play together with each other

in their own studio during the lesson. When playing with backing tracks relayed from the teacher's studio, it was difficult to determine how in-time or out-of-time the students were, as they were responding to the backing track with a slight delay due to the latency. This delay was further compounded when the signal carrying the student's response was returned to the teaching studio.

### 4.4.3 Summary

Of the four events logged over the 25 face-to-face lessons, the most frequently observed event was that of the teacher and student playing the same part together at the same time (*n* = 153). This was used as a form of 'scaffolding' (Nordlof, 2014) during guided student practice, particularly with younger, less experienced students to assist with timing and phrasing.

The teachers also accompanied the students during the lessons (*n* = 78), but owing to issues of latency, instrumental teaching via standard videoconferencing platforms allows only two of the four observed interventions in face-to-face lessons: teacher demonstration (*n* = 151) and playing to backing tracks (*n* = 66). These two interventions were used slightly less frequently than the interactive interventions, and while they allow students to progress musically, if used exclusively, they do not expose students to the full range of playing possibilities that come from playing together with a teacher or other students in a group lesson.

The lesson observations were limited in number and the study was intended only to give a snapshot into the frequency with which students and teachers played together in lessons. A further study with a larger number of teachers and students, in a wider range of instrumental disciplines (including voice) and conducted over a longer duration would be necessary to draw any firm conclusions. Thus, while it is not possible to generalise from the findings, they confirmed my view that playing together forms an important part of face-to-face instrumental music lessons.

## 4.5 Study 4: Music teacher responses to COVID-19 on social media forums

### 4.5.1 Introduction

Though supplemental and not part of my original planning, Study 4 gave me access to the views of hundreds of teachers, which under normal circumstances would have been difficult to carry out. The aim was to understand how instrumental music teachers were adapting their face-to-face teaching to the online teaching environment in the rapidly changing situation circumstances of COVID-19 restrictions.

Social media are now recognised as being an important part of the professional lives of teachers. Platforms such as Facebook and Twitter provide 'teaching communities', and professional learning, professional development, and support groups (Bergviken Rensfeldt et al., 2018).

Waldron et al. (2020, p.1) argue that:

> […] the application of questions, ideas, theories, methodologies, and research from the field of new media and communications has the potential to be as influential and transformative to the field of music education as have the intersections between and among music education and philosophy, psychology, sociology, and education.

Parry (2020) describes how the COVID-19 lockdown of March 2020 accelerated the shift to home and remote working. The shift came as a shock to many different categories of workers, who had to quickly adapt to unforeseen circumstances, including having to manage educating children while simultaneously working at home. This rapid shift to home working also affected instrumental music teachers, many of whom had never previously taught online, yet were having to make the rapid 'pivot' to teaching online, in many cases with little guidance. In these circumstances, many new social media music teacher groups were formed, and existing groups gained new members seeking guidance and advice.

This study monitored nine music teacher support groups on the Facebook platform. There was a mixture of privacy settings for the groups; most were public, in which any Facebook member could see posts from other members in the group, whereas in private groups, only members of the group could see posts from other members. Some groups started as public but changed to private as the number of members rapidly increased.

Extracts of conversations were copied and pasted to Word documents and held securely on password protected devices. All posts and comments were anonymised; no direct quotations were used, and all identifying features were removed to maintain user privacy and confidentiality. No sensitive or controversial topics were included. The dataset was then coded and analysed, and relevant themes identified.

The online discussions included technical considerations including hardware, software, how to maximise home Wi-Fi signal, and positioning of equipment and lighting. Other discussions included the structure, delivery, and administration of online lessons; instrument-specific issues; safeguarding issues; attitudes to online lessons from parents and students, as well as teachers' own self-reported attitudes; and not being able to play together. Representative samples of some of the comments are presented in the following sections.

### 4.5.2 Technical setup

Achieving optimum camera views was a frequently discussed topic along with using multiple devices to achieve different camera views. Display screens were also discussed: 'My eyes are strained from looking at small screens. I would like to use a large TV screen so I can get up and walk around the room and not feel caged in one place'.

Choice of platforms and problems with connectivity was an ongoing debate with many teachers asking for recommendations about the best online platforms and audio equipment to use.

Poor quality of sound was also a frequently reported issue:

> How do we get the best audio quality? I've done trial lessons via Skype and FaceTime before, and while the audio quality is good enough for basic stuff, it's nearly impossible to talk about nuance and colour due to sound quality.

In a percussion teachers' forum, multiple-microphone options were discussed for using on the Zoom platform: 'What is also great about Zoom, unlike Skype and FaceTime is that you can use multiple microphones. So, I am able to have one distant mic for the instruments and one close to the computer for speaking'.

Teachers reported experimenting with different platforms, but the consensus was that Zoom offered the best solution due to its additional functionality with screen share and whiteboards, and options for optimising the audio.

### 4.5.3 Teaching styles and resources

Experienced videoconferencing teachers shared suggestions that included breaking tasks down into smaller sections rather than one assignment containing a whole week's worth of information. They also suggested creating short asynchronous videos explaining the lesson overview, rather than relying on students reading documents. Immediately after lockdown, this gave students the opportunity to see their teacher and regain some feeling of familiarity.

Various suggestions were included for sharing screens, particularly of PDFs of the sheet music which the teacher could annotate in real time for the student. Some teachers requested recommendations for systems that replaced the traditional notebook. Responses included Evernote, an online notebook that can be shared with parents and students, and also Google Docs. Some teachers suggested taking a photo of the notes and emailing them to the parent. There were also frequent suggestions to include parents

in the music lessons, particularly for the first online lesson to help with setting up the technology.

### 4.5.4 Safeguarding

Parents were seen as important in ensuring safe practice, though the advice was mixed. Some teachers suggested asking for the lesson to take place on the parent's device and asking parents to be present at the start and end of calls. A contradictory response was posted, suggesting that parents should not be present in the lesson as students may react differently with a parent present.

There were also mixed responses to the issue of recording lessons. Some schools and Local Authorities insisted on recording online lessons to protect the staff from accusations of inappropriate behaviour during the lesson; other Local Authorities prohibited recording lessons. A typical teacher comment was:

> It's a minefield, but not insurmountable. Most stuff is just common sense - agreement from parent, using a parent's device, using a parent's contact email, in a shared space, appropriate dress, parent present at start of call and stays in vicinity. The greyest area is the one of recording. My personal opinion is that I will record it for safeguarding reasons and give my word that it won't be viewed, copied, reproduced, etc. and will be wiped when things go back to normal. I'm not happy being recorded by students however as I lose control and goodness knows what could happen with images/video.

Storage of recordings presents a practical issue. Video recordings take up a large amount of data and it may not be possible to store more than a few recordings locally on a device, while cloud storage can be costly. There are also legal issues around General Data Protection Regulations regarding how long recordings can be stored before.

Many teachers shared stories of students' home life intruding on the music lesson. These ranged from pet dogs barking loudly in the background, to siblings arguing and fighting, and even on occasions family members being

inappropriately dressed in the background, seemingly unaware that they were visible on the teacher's screen.

### 4.5.5 Attitudes

Many teachers shared emotions ranging from jubilation at having successfully managed the pivot to online teaching, to utter frustration. A sample of comments follows:

> Day two of online lessons was a success! I've learned so much through this whole process and come to a new place in my teaching; I had never seen myself becoming an online teacher.

> For me, online teaching has proven to be a huge success. Even though I was a little apprehensive with my first online lesson, there was no need to be, and I've found it engaging and fun for both the student and me. While adults have been more worried about the move, they have been really positive and are enjoying lessons online in the comfort of their own home with a cup of tea in hand.

One teacher listed positive aspects of online lessons including: not having to travel, less interaction with parents wanting to stay behind to chat after lessons, and being able to see the pupil's home practice environment.

Negative comments were largely to do with discomfort and exhaustion: 'Anyone else finding online teaching exhausting, or am I just not used to it yet?', and 'My ears are hurting from headphones, and I'm losing my voice'. A response from a frequent participant in the forums was: 'I'm seeing the trend of people finding out what I've known for years, that teaching online is more tiring than teaching in person. It doesn't have to be'. Suggested solutions include using less energy when teaching online, taking regular screen breaks, and keeping hydrated.

### 4.5.6 Loss of being able to play together

Not being able to play together was also a frequently cited cause of frustration. In the first two weeks following lockdown, teachers and students

who were unfamiliar with online teaching asked for suggestions for how to play together:

> One of the things that frustrated me when I previously took online lessons was, due to the video delay, I could not play along with, do duets with or jam with my teacher. Do you have any suggestions as to how I can make that sort of interaction more meaningful through online lessons?
>
> I'm hoping for some insight into how to eliminate delays so I can help my young students count in real time. Is there a way to actually play together on any of these remote platforms?

Some participants suggested trying low-latency software such as JamKazam and Jamulus, but the response was not positive as the technologies at that time were seen to be unreliable and ineffective.

### 4.5.7 Summary of comments from social media forums

Many teachers that were new to online teaching asked about platforms that would facilitate playing together, demonstrating a strong desire from the teaching community for an audiovisual system that facilitates playing together, combined with high-quality audio.

After some initial uncertainty, many teachers reported being pleasantly surprised with how easily they adapted with the pivot to videoconferencing, with some deciding that they would continue teaching online either wholly or partly in the future.

Many of the topics covered in the online forums overlapped with the previous studies. One issue that had not previously been addressed was safeguarding of students. This was a particular issue for teachers used to teaching students face-to-face in schools, and then teaching online from their own home to the student's home, with potential privacy issues from both parties.

## 4.6 Discussion

### 4.6.1 Introduction

This set of studies was conducted between 2015 and 2021. During 2020, the COVID-19 crisis forced a paradigm shift in the attitudes of education leaders, teachers and students towards technologies and online learning. The acceleration of developments in technology have often left mainstream education lagging behind, but since the COVID-19 lockdown of March 2020, online earning is no longer an add-on to mainstream education, it has become an integral part.

As lockdown restrictions ease, education institutions at all levels, from schools to Higher Education, are grappling with how best to include online learning alongside face-to-face learning in a blended approach. Videoconferencing technology is now accepted as a means of delivering instrumental music lessons, though there still appears to be a presumption in favour of face-to-face lessons.

Study 1 from 2015 revealed that at that time, the small sample of teachers I interviewed were enthusiastic about using technology and reported that their students were similarly enthusiastic. Smart phones and tablet devices were widely used for teaching, especially for making audio and video recordings during lessons. Study 2 was wider ranging, including teachers and students from different instrumental disciplines and across the education sector including schools, Higher Education and also private teaching. Videoconferencing was used for a variety of reasons, largely for the convenience of not having to travel for lessons, but also facilitating lessons where face-to-face provision was not available. Other uses broadened the reach of Higher Education, including auditions, masterclasses, trial lessons with teachers at different institutions, supplementary lessons to augment lessons with a principal teacher, and lessons when the student or the teacher were physically apart due to touring. Teachers also benefitted from professional development opportunities in watching students working with other teachers in masterclass settings.

Study 4 documented how teachers turned to social media forums to ask for help and advice during the pandemic, and this provided a fascinating insight into how teachers were able to rapidly adapt to teaching via videoconferencing. Most teachers were able to use equipment they already had at home including laptops, tablets, and smart phones. Many teachers reported that having been forced to use videoconferencing for the first time during the pandemic, they would continue with some online teaching in the future.

Some younger students and their families stopped engaging with instrumental teachers during the pandemic for a variety of reasons. For some students, they did not have adequate technology or a suitable environment at home; for others, they were overwhelmed with the amount of schoolwork being set online. Concerns were also raised about the importance of safeguarding students as well as teachers with the sudden change to teaching online.

Studies 1, 2 and 4 revealed mixed views on whether videoconferencing would ever completely replace face-to-face lessons, but most teachers thought it could not, and should not. There were also concerns raised that students receiving remote lessons should still be exposed to rehearsal and performing experiences with other musicians. For advanced students wishing to learn in a particular style or tradition, they may feel there is a loss of authenticity and culture by learning remotely and face-to-face lessons may therefore be essential.

### 4.6.2 Research question 1: What changes in the quality of the interactions and the learning and teaching experience in lessons between face-to-face, standard videoconferencing, and low-latency environments?

Evidenced by data from Study 2 and Study 4, the experience of videoconferencing was found to be intensive and tiring due to the hyper-focus required when working in the remote environment. Teachers also spent longer preparing resources in advance and following up lessons with additional

support materials. Time was distributed differently, especially during group lessons where it was important to keep all students engaged.

The quality of the experience in the videoconferencing lesson was dependent on a variety of factors, including the technical equipment available (e.g. microphones, cameras, monitors, speakers/headphones); the quality and stability of the network connection; the studio environments of both locations; the presence of other parties such as technicians or family members to support or hinder the lesson; and the attitude and experience of both the teacher and learner.

Teachers experienced several challenges when transitioning to teaching via videoconferencing. The first was the choice of equipment and which videoconferencing platform to use, followed by positioning the equipment in their studios, and also coaching students in setting up their own studios. Having extra microphones and cameras and bigger screens can improve the experience, but it also introduces the potential for greater technical problems. The more advanced setups are therefore better suited to an HME environment where there will likely be technical support, rather than a domestic environment.

The second challenge teachers reported was initially feeling anxious about the videoconferencing environment, but many quickly adapted, and their initial apprehension was overcome, as evidenced in Study 4. Thus, attitude and mindset are important.

The third challenge was the physical disconnect and not being able to adjust posture or tune instruments as evidenced by Teacher J (pipes) in Study 2. Teachers found ways to adapt to this, including the use of metaphor and making short instructional videos to be shared in advance (Teacher P, Study 2).

There were mixed views about the importance of the visual element. As reported in Study 2, some teachers felt they were able to teach using just

audio, but others felt the visual element was essential for checking posture and reading facial expressions to check understanding (Teacher I and Teacher J).

### 4.6.3 Research question 2: Are some elements of music instruction more or less effective in face-to-face and standard videoconferencing environments?

The following themes emerged from the findings of Study 2: the rationale for using videoconferencing, technical quality, the learning and teaching environment, loss of physical presence, the importance of the visual element, change of teaching practice, the limitations of videoconferencing and authenticity of learning remotely, the importance of playing together in lessons, implications of using videoconferencing.

The findings showed that videoconferencing had some advantages over face-to-face lessons. Segments of lessons could be quickly and easily recorded for review between lessons, different camera positions were used to give viewpoints not so easily achieved in the face-to-face lesson including overhead shots, and the teaching environment was less noise intensive, a particular consideration for disciplines such as brass and percussion. Lessons could also be more productive as teachers and students could be set up and ready to play, with a greater focus on playing than social interaction.

Limitations of videoconferencing included the physical aspects of some instruments being difficult to teach and learn remotely (Teacher J, Study 2); students missing out on cultural elements by studying remotely, rather than immersing themselves in the cultural milieu (Student L, Study 2). As noted above, the quality of the technical equipment and the quality of network connection was an important factor, and many teachers commented on poor audio quality with its lack of nuance and tone colour being a disappointment (Teacher F, Study 2). Another important consideration is reported that not being able to diagnose postural problems in the remote lesson could lead to

long-term problems for students. Not being able to play together with students was a major consideration and will be discussed more fully in Section 4.6.5.

### 4.6.4 Research question 3: What are the barriers to using videoconferencing in educational settings, and how can these be overcome?

The main barrier to using videoconferencing in education settings was the attitudes of teachers. From Study 1, those teachers with little or no experience of videoconferencing understandably had some reservations, citing concerns about not being able to adjust posture or instruments, and the stability and reliability of the technology. A loss of social connection was another concern about videoconferencing cited by teachers from the first study. However, the interview data from the second study did not show a loss of social interaction to be a problem.

Thus, some initial preconceptions that teachers may have had about using videoconferencing were unfounded. However, other concerns were evidenced by the data; for example, the technology is not always reliable, and being able to adjust posture and instruments remotely requires creative strategies. Nonetheless, the pandemic has undoubtedly changed perceptions and attitudes about videoconferencing, as evidence by Teacher P, Study 2, and also teachers posting on social media forums from Study 4. Teacher P felt that the experience of teaching via videoconferencing during lockdown had a profound effect on how they taught. They wished to retain some of these elements in the future, for example, including more peer-to-peer collaborative work and encouraging students to share performances online.

More pre- and in-service training for teachers in using these developing technologies will help to build confidence and change attitudes, as will technological advances in audio and video equipment, and improved networks.

### 4.6.5 The importance of playing together

As reported in Study 2 and evidenced in Study 3, the major limitation of videoconferencing was students not being able to play with their teachers. Playing with others was one of the elements identified in *A Common Approach 2002* (Federation of Music Services and National Association of Music Educators, 2002), and there is much evidence on the benefits of learning to perform with others (Hallam, 1998; Ley, 2004; Mills, 2007; Rife et al., 2001). The literature also shows that group music making has social as well as musical benefits, and may contribute to feelings of social inclusion (Minguella and Buchanan, 2009, cited in Hallam, 2015)

In order to play together with others, a secure sense of timing is required, and this is often developed through learning to perform alongside the teacher (Welch et al., 2014). Pouthas (1996, p.115) writes: 'Music is commonly said to be the art of time. It is clear that the development of musical competence is partly related to the development of temporal competence: perception of duration and rhythms on the one hand and temporal regulation of actions on the other hand'.

Based on the literature and the findings from Study 1 and Study 2, I developed the view that playing together formed an important part of face-to-face lessons. I was not able to find empirical data in the literature, which led to my third study, an investigation into the frequency with which teachers and students perform together in face-to-face instrumental music lessons. The findings from my third study supported my view that playing together was an important part of face-to-face lessons.

Ward (2019) describes virtual jam sessions for the Online Academy of Irish Music. Listeners could type questions to performers using a chat function, but this was the only form of interaction. Listeners could play along remotely, but they were effectively passive listeners and could have been playing along to a recording of a live session.

While most teachers from the interviews expressed frustration at not being able to play together with students when teaching via videoconferencing, an unexpected finding arose from interviews with two highly experienced teachers in the videoconferencing medium. They did not express a strong interest in playing together with students, feeling that they had largely overcome this with the use of backing tracks. More recently, Stinton (2020) goes further and describes discovering that latency could be an advantage, using it to achieve a certain type of vocal training not so easily achieved in the face-to-face setting:

> Most surprising of all in working online was that by conducting practical virtual classes, a new vocal process was uncovered which students found beneficial to their developing singing technique: back-phrasing. This new approach only emerged due to live, real-time sound a-synchronicity and, as such, it positively repositions the online virtual time lag phenomenon as advantageous in certain situations, rather than merely challenging (Stinton, 2020, p.36).

Nonetheless, given that teachers interviewed in Study 1 and study 2 wanted to be able to play together with students in remote lessons, I decided to focus my later research on low-latency technologies that would facilitate playing together.

### 4.6.6 Final reflections

The experience of the pandemic has caused some teachers to re-evaluate the purpose of instrumental teaching, and to look at more collaborative and explorative ways of teaching through online methods. There is also an opportunity for teachers and students to engage with new audiences by sharing recordings and performances online.

This chapter has explored data from five teachers in Study 1, 10 teachers and two students from Study 2, and many comments from teachers in Study 4 to determine what changes in the experience between face-to-face lessons and videoconferencing lessons. The next chapter reports on autoethnographic

studies using videoconferencing and online learning from my own dual perspectives as a teacher and a learner.

# Chapter 5: Autoethnographic studies

## 5.1 Introduction

This chapter reports on studies using my own personal lived experience of both learning and teaching using videoconferencing and online resources. The chapter is organised in nine sections: introduction; data from two studies with myself in the teaching role with an adult marimba student and two beginner drumkit students; my experience of teaching school students during COVID-19; my reflections on using videoconferencing as a learner, becoming part of an online musical community, informal learning, and MOOCs; and a discussion section.

I am reflecting on my practice in different domains as a musician, teacher, learner, and researcher, in order to become, as López-Íñiguez and Coutts (2020, p.4) describe, 'mindful of the changing landscape of our profession and of the implications for our teaching practices'.

Autoethnography seeks to describe and analyse personal experience in order to understand wider cultural experience (Ellis et al., 2010). Critiques of autoethnography include conducting too little fieldwork, observing too few cultural members, not spending enough time with 'different others' (Delamont, 2009), or using biased data (Anderson, 2006). However, Ellis et al. (2010) argue that autoethnographic research can be rigorous, theoretical, and analytical, and that as a method, autoethnography acknowledges and accommodates both the researcher's subjective views, and their own influence on research, rather than denying their existence.

Music researchers are often connected to social networks that include other musicians, teachers, students and research institutions. These relationships with others are not normally regarded as simply means to acquire data, but often involve friendships. Thus, relational ethics need to be taken into account when conducting autoethnographic research as by writing about themselves, autoethnographers also implicate others through their writing (Trahar, 2009).

My experience of *learning* via videoconferencing began in 2010 and has continued since. My experience of *teaching* via videoconferencing began a year into my doctoral studies. Through fully immersing myself in these activities, I became more aware of problems with learning and teaching via videoconferencing which allowed me to ask more pertinent questions of teachers and learners from an 'emic', or insider, perspective during other parts of my research.

More importantly, what started as a small part of my research became an essential part of my teaching practice in March 2020 in response to the COVID-19 pandemic. The experience gained through my research informed how I taught in practice, and I was able to draw on examples of best practice.

## 5.2 Study 5: Teaching an adult marimba student

### 5.2.1 Introduction

My first experience of teaching via videoconferencing was teaching an adult student four-mallet technique for marimba (Participant H). The participant had prior experience of percussion training whilst at school, as well as experience of teaching in the online environment as a lecturer and was interviewed in the previous chapter (Section 4.3) to discover their experience of using videoconferencing as a lecturer. Participant H was keen to develop not just marimba technique, but also to try learning via videoconferencing. The aims of the study were to discover whether it would be possible to teach four-mallet technique via videoconferencing, and to trial teaching using videoconferencing.

We were both already 'converts' to videoconferencing; Participant H used videoconferencing as a lecturer at a HEI, and I used videoconferencing as a learner. We reversed our roles with regards to our previous experience as teachers and learners, and entered into the arrangement with a positive attitude and a spirit of exploration. In considering my approach to teaching via videoconferencing, I drew on many years of experience of teaching in the

face-to-face environment, as well as my own experience of receiving online lessons.

Four-mallet technique is considered a specialised percussion technique for keyboard percussion instruments including marimba, vibraphone and xylophone. It allows a player to strike up to four notes simultaneously, allowing performance of single line melodies as well as chordal textures. Compared to other instruments such as piano and violin whose performance practices are centuries old, marimba pedagogy is still in its infancy (Zeltsman, 2003, preface p.v), with relatively few method books available, and new methods and techniques are still being developed.

There are various four-mallet methods and techniques; the two main methods are referred to as cross stick, where the shafts of the two mallets cross in the player's hand, and independent grip, where the mallet shafts are held in different parts of the hand and do not come in to contact (Stevens, 2008). These can be broken down into further sub-categories, with methods often named after individual players, such as Burton, Musser, and Stevens. The choice of which technique to use is largely personal, though it will rely to a certain extent on an individual's hand size and shape and the technique recommended by their teacher.

The main differences between techniques lies in mechanical operation (i.e., the way in which the mallets open and close, and the way each mallet shaft is gripped). Each technique has its own advantages and disadvantages, but in essence, whichever technique is used, all players face the same challenge of opening and closing the interval between the mallet heads, sometimes rapidly, while maintaining stability with the grip (Stevens, 2008).

These methods and techniques are not easily learned through reading method books or following diagrams. I have attended international marimba seminars and festivals to explore these techniques in detail with world-renowned players and teachers. I was therefore intrigued as to whether it would be possible to teach four-mallet technique via videoconferencing.

I kept a written record of work covered in each lesson, along with lesson notes emailed before and after each lesson, and a log of any technical and pedagogical issues that arose during the lessons. I also conducted three interviews with the participant via Skype during the course of the lessons to discuss their experience and to check the lessons were meeting their expectations.

### 5.2.2 Lessons

The lessons were conducted via the Skype platform over a period of nearly two years between September 2015 and June 2017, during which time the participant developed four-mallet technique and was introduced to standard marimba repertoire. Each lesson lasted approximately one hour, with lessons spaced two to three weeks apart during term-time, giving the participant time to work on exercises and repertoire between lessons. The participant used a laptop computer for ease of portability, whereas I initially used a desktop iMac computer which afforded me a larger screen, but eventually I used a laptop computer for convenience. The computers were set up with our respective cameras giving a front or 'audience perspective', and so we could also see our own screens easily. We also used the built-in microphone and speakers on our computers rather than external devices.

The participant initially used their university music department facilities and marimba for lessons, but subsequently purchased their own marimba and had lessons in their own home. I taught from various locations in my own home due to having limited space and not having a dedicated studio. Despite owning a 5-octave marimba, I was rarely able to set it up at home due to the considerable size of the instrument, so I used a vibraphone and a MalletKAT MIDI mallet keyboard.

The initial lessons consisted of working on simple exercises and repertoire, and demonstrating and working on two basic grips, Burton (i.e., crossed grip) and Stevens (i.e., independent grip). This involved me holding my hand position close to the camera for the participant to observe, and then giving

detailed commentary while the participant copied the grip and subsequently practised on their instrument. Burton grip was eventually agreed upon as it provides stability, particularly in the early stages of learning. Four basic stroke motions were practised: single independent, single alternating, double vertical, and double lateral.

I prepared exercises, studies and repertoire using the music notation programme MuseScore. These were then converted to PDF and sent in advance of each lesson via email as file attachments, giving the participant time to download and print them before each lesson. MP3 backing tracks were also prepared using GarageBand and sent in advance. Additional notes were also sent to the participant following each lesson. Thus, preparation was heavily time consuming.

Shortly after lessons begun, the participant acquired a marimba method book, chosen due to its useful mixture of exercises, study pieces, more advanced repertoire and general tips and advice. This made lesson planning more flexible, and in some respects more similar to a face-to-face lesson, as exercises and repertoire could be chosen during the lesson, rather than having to rigidly stick to a pre-prepared schedule. As lessons progressed, the participant obtained additional repertoire, some at my suggestion, and some of their own choosing. Music theory and general musicianship concepts were added to the lessons to try and assist the participant in achieving their goal of playing marimba in ensembles. The participant subsequently performed at ‘Celtic Connections’, a major music festival in Glasgow.

### 5.2.3 Reflections on the learning and teaching experience

My experience was that the participant's sound from their marimba was mostly clear and undistorted. The participant commented on the audio quality from my studio and had mixed views:

> I think it's mostly really good, and it's absolutely fine for the kind of teaching when you're talking about things; maybe not so much for demonstrating, I don't know whether it's something about that

> particular instrument [vibraphone], it distorts really badly […] it's just not a particularly nice sound.

I subsequently changed to using the MIDI MalletKAT instrument through a speaker placed near to the laptop microphone which improved the sound quality for the participant.

We discussed the video quality: ‘Your end is really good, you've got it set up really well, I can see everything I need to see’. With a mid-distance front view, I was able to see the participant clearly, including their hand and mallet position.

The network connection was poor on some occasions as acknowledged by the participant:

> We've been quite lucky, I think. We've had a few times at the college when it was pretty bad, and then it just becomes frustrating, because it just takes a long time to do anything. But even when the connection has dropped and we've had to dial up again, that's not really a problem at all. It's more when it keeps happening over and over again like it did at the college. I think it was just once that happened, and then you just think, ‘we'll just do it another day’.

We discussed possible technological advances to improve the experience and agreed that an improvement in internet connection and reliability was essential.

The participant found having materials sent in advance and follow up notes sent after the lesson useful. They commented further: ‘you're very organised […] what you could do if you're teaching lots of people at different levels is have a website with everything on that and just point people in the right direction’, which I later implemented in Study 6.

We discussed the importance with playing with other musicians, and whether the participant felt they had missed out on anything by not playing together during videoconferencing lessons. They did not feel it had been a particular problem for them as they already played in ensembles with other musicians.

When asked about possible improvements to the technology, they commented on the audio switching, ‘if you could hear what the other person was playing at the same time as you were playing rather than it switching back, I suppose that would be kind of nice’.

We also discussed comments from my previous studies where instrumental teachers that had not used videoconferencing thought that it would be difficult to build a rapport with their students (Chapter 4, Section 4.2.5):

> I totally disagree with those people. It was nice to meet you to start with, because it means you kind of know what you're expecting, but actually I don't think it's a barrier at all. I think it may be something that people think might happen, but actually it doesn't.

We discussed what changed in the experience between face-to-face lessons and videoconferencing lessons from their perspective as a learner, and whether we should be comparing the two experiences as being ‘as good’ as each other, or whether it would be better to accept them as different?

> If your goal is to learn an instrument, and at the end of it you learn that instrument to whatever standard it is you want to, then does it matter how you do that? I guess that it's also comparing it to informal learning. I know a lot of guitarists learn from YouTube videos; it's still learning, but in a different way.

> I wonder whether the thing that makes people scared about it is the fact that you're not in the same room, and I'm wondering if it's the human aspect more than the technological aspect of it? Because it's not difficult to connect via Skype is it, and it's pretty good, so for people that haven't tried it, maybe it's because there's not somebody there to hold their hand.

The participant was enthusiastic about the overall experience: ‘I think it's a really positive thing because it gives access to instrumental tuition that you couldn't get otherwise’. I asked whether they perceived any negative aspects:

> No, and I often think, in a way, having a set time, like you switch on and you do your lesson and then you switch off, is actually quite a

> good thing because it stops you chatting for the first 10 minutes while you hang up your coat.

In summary, I was satisfied that the participant had made such good progress in learning a difficult technique despite the technical challenges from poor internet connections. The participant went on to state, ‘the fact that I can play now with four mallets which I couldn't do, what six months ago is pretty impressive I think, so it proves that it works’.

## 5.3 Study 6: Teaching two beginner drum kit students

### 5.3.1 Introduction

I taught two beginner drum kit students on the Skype platform between January and April 2018. Student Q (nine years old) was already receiving piano lessons and their parents (one of whom is a professional musician, teacher and examiner, Parent S) were keen for the student to try percussion lessons. I had previously taught Student Q in a face-to-face setting in their home on four occasions between January and June 2017, but after I moved to a new location, it was agreed that we would trial lessons via videoconferencing. I also agreed to teach Student Q's older sibling, Student R, who was 14 years old, studying piano and saxophone privately, and playing drum kit in group music classes at school. The aims of the study were to test the complexities of teaching young beginner students via videoconferencing.

Student Q and Student R each had a separate lesson lasting 30 minutes with lessons spaced two weeks apart. Each student had a total of eight lessons via videoconferencing, with a ninth lesson delivered face-to-face. I conducted an interview with Parent S immediately following the final face-to-face lesson.

I based my teaching on the same methods I had developed during many years of face-to-face lessons, beginning with rote learning for basic drum kit styles and ‘fill-ins’, then exercise sheets I prepared myself, progressing to fully notated drum kit pieces with backing tracks published by the Scottish

Qualifications Authority (SQA) for use by students in school certificate music courses.

### 5.3.2 Lessons

Teaching materials were initially shared using Cadenza, an application which at that time was still in development and free to use. The application was designed to support music lessons through a suite of tools which included file sharing of PDFs and backing tracks, lesson planning, a student notebook and reflection log for students to complete after each lesson, and a media annotator allowing students and teachers to upload videos and then add comments.

We found that the students were not checking in to Cadenza regularly after the first two lessons due to login problems, and in consultation with the parents, I switched to Evernote, a free-to-use application (for the 'basic' version) for sharing files, videos and keeping a notebook. The parents also had access to the application which made it slightly easier to ensure that teaching materials were downloaded and printed off in advance.

The first two lessons were delivered via the Skype platform, which at that time was one of the most widely used videoconferencing platforms, and one the parents were also familiar with. The connection was extremely poor during the first lesson and after stopping and restarting several times, we switched to audio only. The connection was also poor on the second lesson, and we subsequently moved to the Zoom platform. From my experience as a learner (Study 8), I had already experienced better connectivity using Zoom compared to Skype, but the procedure for connecting is slightly different to Skype, and I did not wish to introduce too many unfamiliar and potentially confusing elements in the first lessons. We experienced delays in connecting via Zoom on several occasions due to the necessity to login with meeting codes. I sent contact details in advance of each lesson via email and SMS text message, but that also required the students to check their devices for codes in advance of the lessons which added another layer of complexity.

Both parents helped to ensure the students were correctly set up which was invaluable, especially in the early stages of lessons. As the lessons progressed, the students became more familiar with setting up for lessons themselves. The parents were on hand to assist when the device that Student Q was using to connect ran out of charge, and also when the student had problems with pairing a Bluetooth speaker.

### 5.3.3 Comparison between the videoconferencing lessons and face-to-face lessons

The ninth and final lesson was held face-to-face with both students in their home studio, I was able to note interventions that were not possible in videoconferencing lessons. For example, at the start of Student R's face-to-face lesson, I moved the music stand to make it easier for them to read the charts. Since almost all of the videoconferencing lessons had been audio-only, I was unable to observe the position of the music stand and had therefore missed this. I also adjusted the hi-hat pedal and clutch on their drum kit. I marked musical features on the chart in pencil, for example, cymbal crashes which are easy to miss on a score. I was able to point to various places in the chart as both students played along to the backing track, which they found helpful in keeping their place, especially in repeated sections. I was also able to point directly to musical features on the chart to check their understanding, which was much easier than asking the students to find particular bars within the charts via videoconferencing and ensured that we were both looking at the same section. Overall, these changes were particular to setting up musical equipment and also helping the student to find and keep their place in the written music.

I had explained a specialised snare drum technique, a 'flam' to Student R during previous videoconferencing lessons, but it was helpful for the student to see this technique in the face-to-face lesson to appreciate the difference in stick heights, and also for me to check the student was playing with correct stick positions and stick height.

Crucially, I played along with Student Q using the just the hi-hat and snare drum on the same drum kit to help them keep time with the backing track; they reported that it helped assist with their timing. I was also able to play along with Student R on the piano to demonstrate rhythmic 'pushes', or anticipations of the main beat. I was able to stop and start play-along tracks easily during the lesson, and also demonstrate and use the Speedshifter app to slow tracks down.

### 5.3.4 Reflections on the learning and teaching experience

I interviewed Parent S following the final lesson. We started by discussing the students' first reactions to the overall lesson experience:

> To begin with, it was just a matter of getting a good enough signal so you could communicate. It was fairly intermittent; we were getting bits of sentences. They weren't phased by it, it was just, as you say, the technology got in the way initially, and then we went over to audio only and then I think it started to work OK […] if things get to the point where we've got a stable, very fast and reliable Wi-Fi connection, that seems to be a really important aspect, because that enables the communication, that enables a smooth experience.

I asked more about the technical interruptions due to the poor connection, and how this had affected the experience:

> I think [Student R] was more frustrated with the gaps and the technical interruptions than [Student Q] was. I did explain what the project was about, that it was research, that there are probably going to be some glitches. They did understand, but they quite quickly said to me 'I think having the teacher in the room is much better', which is still their feedback. I asked them why, and they felt it was particularly for showing and demonstrating, but also for the audio as well. But from my observations, it did settle down a bit once we had gone on to Zoom, and I think the main thing is that you can hear each other clearly.

We discussed the greater importance of the audio over the video element: 'It showed that you don't need the picture. You could have different cameras at different angles to show various parts of the kit or whatever, but obviously the

audio is the more important element'. I went on to ask if they felt that audio-only was acceptable:

> I think it is. In my own teaching, I tend to be usually positioned at the piano with the student at the side, this would be sax or clarinet. I'm not often looking at them face-to-face, but obviously if you're in the same room together, it's only natural to have some eye contact. I think possibly from your demonstration side of things, which has been very clear, they seem to have been picking it up, but I think that's because of the clarity of your explanations. Your teaching style is very clear, so possibly for someone else, another teacher might be more used to visual demonstrations, and they would have to adapt their style to that.

Poor audio quality was noted by Parent S. I attributed the poor audio quality partly to the poor network connection. Another possible factor was that I was playing an electronic drum kit with the audio directed through a speaker next to my laptop microphone, which may have led to some degradation of audio quality. However, this was important for controlling the volume of the drum kit in my studio, as an acoustic kit would have caused disturbance to my neighbours. Parent S suggested I tried an audio interface to boost the audio quality of the electronic drumkit. I subsequently tested this, but I was unable to discern a noticeable difference in the audio quality. Teachers from Study 2 (Chapter 4, Section 4.3) commented that they were frustrated at never really knowing how the audio quality was received in the student's studio.

The audio quality from the students' home studio was also noticeably variable. For example, there was occasionally a gap in the audio and then the packets of information seemed to come through quickly leading to feedback, echoes, and distortion. However, on the whole, their drum kit was generally clear, and I was surprised at being able to hear individual parts very well, to the point where I could hear subtleties such as the hi-hat being closed, which is difficult to hear even in the face-to-face setting.

We discussed possible ways to improve the experience. Parent S suggested having an array of microphones and cameras, and that having the audio come through a PA system could help to achieve a fuller sound but conceded it

could complicate the lesson and was beyond the reach of most students. We also discussed the importance of the visual element:

> I'm not convinced that you need the visual element, but potentially a nice big 40" screen with you appearing at the drum kit would be very helpful. I suppose anything that makes it feel more like face-to-face is actually going to feel more natural. It's a bit like when you're in a recording studio and you suddenly find that you're in a booth, you're cut off, and everything is going through the headphones, and then you spend quite a long time getting comfortable with that, possibly a couple of hours or three hours on the first day setting all that up. And what you're actually after is to make it feel natural, feel as real as possible.

From an effective teaching point of view, it became apparent that a set of instructions and protocols would be useful for parents and students in setting up equipment and ensuring lessons ran smoothly: 'I suppose one thing that could be really helpful is if there were a guide as to what is going to facilitate the best experience in terms of equipment, because we just grabbed a laptop and a Bluetooth speaker'.

We discussed whether there would be an age limit below which lessons via videoconferencing would not be acceptable: 'No, I don't think there's been an issue there. The thing is that they're involved with technology so early. There's a slight novelty to it but it's nothing to phase them at all'.

We also discussed the importance of the teacher-student relationship, and whether it was necessary to have first met face-to-face:

> I suppose for teacher-student rapport, it's best to actually start off face-to-face, but again if you have the visual element and you have an introductory session, then I don't see why that couldn't be done over the wires as well. It is an important relationship, isn't it?

I discussed my concern that we had not quite refined the organisational system of sharing resources and practice notes. I felt it was important to have all the notes and resources in one place, as opposed to scattered throughout various emails and that the students should be able to access this easily:

> The traditional scenario is that the student turns up with their instrument and a bag with their music and a practice diary in it; everything is together there. […] I thought it [Evernote] looked really good because you can have a notebook with the lessons in it, and because we're dealing with such a large range of materials. The fact is that pieces of paper end up in piles and it is difficult to keep everything together, so I do actually think the idea of having an online resource is a very, very good idea. It's just the student needs to be in the habit of going there.

Parent S reported that in their own face-to-face teaching practice, they played together with students 'a lot, most of the time'. We discussed the importance of playing together in lessons and group teaching situations in more detail.

> I think, probably if you asked a lot of the students what it was that they most got out of it, it was the experience of playing with each other, getting ideas from each other, and that would be very difficult to replicate. […] That thing of playing with others on the band stand […] in many ways, for someone to play music like jazz, it's a real classroom, you learn so quickly doing that, I don't think it's something you can easily replicate through technology. There is also a physicality to music, we produce sound waves in the room, and we react to that, we absorb it.

We discussed whether face-to-face is still the best experience for lessons, and especially for playing together:

> I would agree that face-to-face is really important […] I had a whole series of lessons with my very first jazz sax teacher, I just turned up to his house, he put on recordings, and we played; he hardly ever spoke to me really. I learned a huge amount. I don't think you could really experience that through online. That was very much a type of learning that I needed to be in the room.

> I think you could achieve a balance […] a colleague and I were talking about having some online resources to support students, and we would actually be in contact with them between the courses. It never got there, just because the investment would have been so huge really, both in time and cost. Because we had students travelling a long way, we would see them for a couple of days on a course, and then we wouldn't see them for two months, but there could be support.

I asked Parent S their view on me not physically being present for the lessons:

> The fact that you weren't here wasn't a big barrier. You came to the lessons very prepared as a teacher, your communication and instructions were very clear, so it seems to me to rely on the teacher being very prepared.

I finished by asking their opinion on how videoconferencing lessons could complement face-to-face lessons:

> I think it could have its place in the learning experience, but with technology as it is at the moment, from what we've experienced it has its limitations and if it's used for a certain purpose, as we've been talking about, certain types of learning, or plugging the gap between face-to-face lessons, I think it's very valuable.
>
> One thing we did all say was in that really bad weather during the winter, everything seemed to be cancelled, everybody was cancelling everything, and yet the drum lessons went ahead! So, there are practical reasons why it's useful.

I used the same curriculum for videoconferencing lessons I used with face-to-face students, with small adaptations to make allowances for not being able to play together with the students or see them during lessons. Both students made excellent progress, with Student Q quickly learning two grade 1 standard pieces and moving onto a grade 2 piece. Student R rapidly progressed from working on basic drum styles taught by rote, through grade 2 repertoire and onto a grade 3 piece. By comparison with teaching weekly face-to-face lessons in school, I found their progress remarkable, especially considering the relatively few lessons they had. However, I do not attribute their relatively good progress directly to the videoconferencing medium itself, which if anything, was a hindrance compared to face-to-face teaching, especially with the lessons being audio-only. My view is that their progress was largely attributable to their own musicianship from already learning other instruments, combined with a supportive and nurturing home environment.

For Study 6, the videoconferencing medium served its purpose and facilitated learning without either the students or myself having to travel; with no local teachers available, the students would not have otherwise been able to learn directly with a teacher. However, I felt that when teaching Students Q and R, the problems with the network connection was off-putting, and had the lessons not had a pre-determined duration of one term, the students may perhaps not have wanted to continue using videoconferencing.

The implications are that: parental support is important for operating the technology, particularly for younger students; online resources need to be easily accessible; the technology needs to be reliable; and that playing together is an important element of lessons, and that wherever possible, students should have some experience of this, perhaps in a blended learning format with a mix of face-to-face lessons and online lessons.

## 5.4 Study 7: Teaching school students online during COVID

### 5.4.1 Introduction

I included this reflection on teaching school students online during the COVID-19 pandemic as it aligned with my research plans. As has been well documented (Diep, 2020; O'Hara, 2020; Parry, 2020; Baines, 2021; Ritchie and Sharpe, 2021; Thorgersen and Mars, 2021), the COVID-19 pandemic forced a dramatic and sudden shift in education in the UK and many other countries to teaching online. Schools had to change their established models of teaching to a hybrid form, and parents and carers took on a new role in assisting that children's learning at home, often while trying to also work at home themselves.

Kim and Asbury (2020) report on the effect the sudden change had on teachers. Six key themes were identified: initial uncertainty about the most appropriate approach and how long the closures would last; thereafter finding a way forward; concern for vulnerable students; the importance of strong relationships with students, parents, and other teachers; their own professional teaching identity, and how this was affected by the severe

disruption to their normal planning, routines and structures; reflection on how to use their learning during this period to improve students' educational experiences post-COVID-19. Daubney and Fautley (2020) describe how music teachers have continued teaching groups and individuals using a combination of online resources, recordings, and synchronous teaching. Thus, the enforced changes to teaching due to the pandemic were not implemented in a planned way, but some elements of online education have been retained by teachers.

The issue of equity of access for students is of major concern. It is recognised that not all households have either the musical equipment, the technology, or the space in which to support instrumental lessons at home (Daubney and Fautley, 2020). In December 2020, the Incorporated Society of Musicians (ISM) produced a report titled *The Heart of the School is Missing*, based on a survey of more than 1,300 music teachers across the UK in September and October 2020 (Underhill, 2020). The report states that music education in UK schools faced an unprecedented crisis, with singing and instrumental lessons and extracurricular activities, including rehearsals and concerts, all severely affected. 99% of instrumental teachers reported that teaching had changed for them, with 35% of primary schools and 28% of secondary schools discontinuing face-to-face instrumental lessons (ibid.).

### 5.4.2 March to June 2020: remote lessons in the home

Following the COVID-19 lockdown in March 2020, most Local Authority music services in Scotland were unprepared for teaching online and without protocols or guidelines for online teaching, let alone delivering lessons to students at home from a teacher's own home. Staff were given very little advice on how to teach online, and in some instances asked to contact students via social media, something that previously was not only discouraged, but could have resulted in disciplinary proceedings. The main concern was in safeguarding students and staff while still attempting to deliver a quality service.

Teachers in my Local Authority were asked to use the Microsoft (MS) Teams platform. I was previously unfamiliar with the platform and its features, which included a videoconferencing element with calendar facility for scheduling lessons, and a resources section for uploading and organising teaching materials. Despite my initial unfamiliarity with MS Teams, and teething problems with its stability as so many new teachers attempted to use the platform, I found it performed well.

Out of a cohort of approximately 100 students, I found that approximately 70% engaged with lessons enthusiastically and attended all lessons that were offered; approximately 15% of students attended several lessons but then stopped attending; and approximately 15% of students did not respond at all. I initially sent email invitations to all students, which had a mixed response. In an effort to encourage more students to engage with the online lessons, I also contacted parents and classroom music teachers. I was informed that some students' homes had very poor internet access and that some students were experiencing a high amount of stress.

My experience aligned with other research (Daubney and Fautley, 2020), in that not all students had instruments at home or suitable places to practise, but I encouraged them to attend the lessons anyway. Other students were anxious about attending lessons online, or had difficulties using the technology, and some students were simply not willing to engage with the lessons for reasons that were difficult to ascertain, since students and parents were not responding to emails.

Having initially offered individual lessons, I subsequently offered additional group lessons with students that were from the same class, and then group lessons that were open to all students of the same level from any of my seven schools. This allowed students who may have been anxious about attending individual lessons the opportunity to observe a group lesson, and it also allowed me to trial the one-to-many concept across different sites. I believe that this will be an area of development for school music services, but it also a sensitive topic among staff. In conversation with colleagues pre-pandemic,

there was a fear that if one teacher delivered simultaneous lessons to multiple sites, there would be a diminution in the quality of personal attention that students receive, and also potential job losses.

Due to safeguarding concerns, the lessons were run without camera access from either side, but I created PowerPoint presentations to provide a visual element during lessons. This also made it far easier to direct students to the correct place in the music as I was able to capture individual bars or short sections of music and display these on slides.

In addition to offering videoconferencing lessons, I also created and uploaded a full suite of asynchronous resources to the MS Teams platform between March and June 2020. These resources consisted of PDFs, MP3 backing track files, a series of short explanatory videos for each section of each piece and practice notes, and I based these resources on the type of resources I found in MOOCs. These allowed students to access all the materials appropriate to their stage of learning, and to review any aspect that they wished to between the videoconferencing lessons, or to use them exclusively if they were not attending videoconferencing lessons. The process of creating the PowerPoint slides and asynchronous resources was extremely time consuming. I found I could spend between one to hours producing a PowerPoint presentation for one piece of music, and at least two hours recording, editing, and uploading a series of one-minute videos. However, once created, the resources were available to reuse and refine. The production process also became easier as I became more familiar with Microsoft (MS) Teams and producing and editing content.

### 5.4.3 September 2020 onwards: remote lessons in the school

Prior to the lockdown, I taught in two schools per day. On the return to face-to-face teaching in September 2020, I was asked to teach face-to-face in just one school per day, and to teach at the other school using MS Teams, so as to reduce the risk of virus transmission. I initially tried to teach using MS Teams while based in another school, however, the school Wi-Fi systems

were already working to capacity and the combination of two poorly performing networks resulted in frequent screen freezes and very poor connectivity. I subsequently carried out my online teaching from my home studio where I had far better internet access. I used an ethernet cable, a halo light for improved visibility, and I was able to set up multiple camera angles using a laptop as well as an iPad tablet. I created a rota so that, where possible, I taught students on an alternating basis of one week of face-to-face lessons with online lessons the following week.

Students were issued with iPads via the Local Authority, and these were used for connecting to the Teams lessons. Some students needed assistance with connecting for lessons in school; this was provided by classroom teachers or in some instances, senior students. Students in lessons were sometimes interrupted by students from other classes coming into rooms to borrow equipment, and there appeared to be an element of anxiety in younger students about being in a room without a teacher physically present.

The situation repeated with a second lockdown from January 2021, followed by a return to blended learning in schools from April 2021.

### 5.4.4 Reflections on the online teaching experience since March 2020

The emergency pivot to online teaching forced through changes to teaching practices that under normal circumstances would have taken months or even years of deliberation. The MS Teams platform was untested at this scale, but after a lot of disruption to the platform immediately following lockdown, I was pleasantly surprised by how stable Teams was in comparison to my experience with using Skype just two years earlier (Study 5). Students occasionally had difficulty in connecting to Teams, and on other occasions, screen sharing only worked for some students, but not for others. Scheduling lessons was easy using the integrated calendar; the system automatically sent invitations to students by email from where they joined sessions by clicking on the attached link. This was a considerable improvement on my

previous experience using both Skype and Zoom platforms, and it also ensured students could quickly and easily check their lesson time.

Approximately 70% of my students found it helpful to continue with lessons during lockdown, so as to maintain some kind of normality by having regular contact with a familiar and trusted adult. However, students did still fail to attend lessons, whether through forgetfulness, not wanting to participate, or in some cases, oversleeping. I recognised that many students experienced anxiety, loneliness and depression during this period, as also reported by Cauberghe et al. (2020). On average, of the approximately 70% of students that regularly engaged with lessons, there were far fewer missed lessons compared to the face-to-face setting since they received reminders on their iPads via MS Teams.

Students generally responded well to remote lessons taking place in schools (during the time when I was only permitted to visit one school per day), though some stated a preference for face-to-face lessons. Students that were shy in face-to-face group situations were generally much more confident in the online environment; conversely, students that were performing well in face-to-face lessons prior to COVID-19 either did not adapt well to learning in the online environment or did not attend lessons at all. The reasons were complex and difficult to understand as in some instances, communication with students and parents ceased altogether, which aligned with the findings reported by the string teacher from Study 4, Section 4.3.11.

During this period, I was fortunate in being able to draw on my prior experience of teaching via videoconferencing with an awareness of many problems my students may experience, including poor Wi-Fi, poor audio, no video, and disturbance from others in the house. I was confident in my ability to teach remotely, and I believe that this in turn helped the students to feel more relaxed. Colleagues and managers asked to sit in on my lessons to observe good practice as most had no prior experience.

My main concern from this experience was that a small but significant proportion of students were not fully engaged with the online learning experience, despite all students being issued with iPads.

## 5.5 Study 8: Online lessons as a learner

### 5.5.1 Videoconferencing lessons as a learner

My first experience of videoconferencing lessons as a learner was in 2010. One of my school students had taken a performing exam on pipe band snare drum, a specialised area of performance for which the Scottish Qualifications Authority (SQA) send specialist examiners to schools. I was able to support the student in preparing for the exam, but I wished to expand my knowledge of this style of drumming. The examiner was a world-renowned performer and I made contact following the exam to enquire about taking pipe band snare drum lessons for myself. The examiner was not available for lessons but passed on contact details for a teacher offering lessons via Skype, and so began my first steps into learning via videoconferencing.

Over a series of four lessons, I worked through the SQA published pipe band drum repertoire. Whilst I was already familiar with standard snare drum rudiments, there are certain stylistic idiosyncrasies with pipe band drumming that are difficult to follow from notation alone. It was essential for me to not just hear the pieces demonstrated, but to be able to play excerpts back to the teacher for comment and further refinement. I would have liked to have been able to play along with the teacher, as in a pipe band drum corps, but the technology did not facilitate this.

We each used our laptop computer's built-in webcam via Skype. The picture quality was poor and heavily pixelated, to the extent that I would not be able to recognise the teacher had I met them face-to-face. The audio quality was also poor, but I was able to hear well enough to pick up some dynamics and nuances of expression. The connections were often unstable; for some lessons there were just a few interruptions, in others we had to restart the Skype connection multiple times.

Despite the challenges, my first experience of learning via videoconferencing was positive and I was pleased with the progress I had made. It was particularly useful not having to make a 200-mile round trip, saving time, expense, and unnecessary environmental damage. I also had the added convenience of being able to warm up before each lesson, and to continue practising immediately after the lesson.

I have subsequently studied jazz vibraphone, jazz piano, and jazz 'language' via videoconferencing with a variety of different teachers based in the UK, USA, and Canada, including a teacher at Berklee College of Music. Each teacher had their own personal preferences of platform: Skype, FaceTime, and more recently, Zoom. The technologies have improved dramatically since my earliest lessons in 2010, with improvements in network stability, picture quality, and most importantly, audio quality. However, none of these platforms have so far facilitated playing together, an important part of being a jazz musician.

The experience has, unsurprisingly, been different with each of the teachers. Some teachers have typed notes during the lesson and emailed them immediately at the end of each lesson. Others have made in-lesson video recordings and then sent them for review a day or two after the lesson, the delay caused by the amount of time needed to 'render' the videos. One teacher added notes to a folder using the Evernote platform, whereas another teacher referred me to specific pages in published books during lessons. I found it useful to be able to instantly turn to a printed book with all the information in one place, without interrupting the lesson flow by having to download or print copies. This may be due to having grown up with print copies and having an unconscious bias towards this format, but it is more likely explained by the convenience of having the printed page readily available.

Not having a dedicated studio space in a previous home was somewhat problematic as I needed to work around family life and also be mindful of disturbing neighbours through thin partition walls. Teaching and learning at

home can also bring unwanted intrusions, including pets, other family members, or deliveries to the home.

Videoconferencing has undoubtedly opened up new possibilities for me to study, and I drew on the experiences of best practice from each of these teachers in my own teaching practice.

### 5.5.2 Becoming part of an online musical community

Waldron (2012a) notes that musicians may find as much meaning from participating in online music communities as offline communities, and goes on to discuss how online learning often converges with offline 'real world' learning in musical communities (Waldron, 2012b). According to Waldron, online communities can be 'much more sophisticated in terms of content, breadth, depth and organisation than anything that currently exists in the formal music education community' (Waldron, 2012b, p.101), and that combining formal learning with informal learning practices can produce richer musical experiences as 'the local becomes situated in the global and vice versa' (Waldron, 2009, p.108).

Even before COVID-19, the imperative to reduce climate change from greenhouse-gas emissions, particularly from flying, began a trend towards holding conferences online. Organisations such as the European Society for the Cognitive Sciences of Music (ESCOM) were responding to this challenge and published a position paper on climate change in August 2019, in which they set out their aims to reduce carbon emissions by experimenting with virtual and semi-virtual conferences, using 'emerging and improving technologies for electronic communication' (ESCOM, 2019). Thus, it is posited that many more conferences and music events will be held online in the future.

The World Vibes Congress began in 2014 as a live event in New Jersey, with the aim of promoting all aspects of the vibraphone. Attending the event in previous years entailed considerable outlay for participants in terms of travel

and accommodation and though I was keen, I was unable to commit the time or the money. In January 2021, the event was held for the first time as a free live-streaming event on YouTube. Hosting this event online allowed many musicians from different countries, including myself, to participate in the event, and also reduced the environmental impact. However, the downside to holding events online is that participants do not have the opportunity to interact and socialise in the same way as live events.

The main purpose of participating in face-to-face music workshops is to rehearse and perform with other musicians in real world settings. Another benefit is to meet and socialise with other students, and to form a network and community. I have enjoyed the opportunity to meet new people and discuss musical and performance aspects in a relaxed and social setting at workshops, conferences, and seminars. For example, I attended a marimba seminar some years ago at the Conservatorium van Amsterdam. During breakfast at the hotel with a group of delegates from different countries, the informal conversation turned to a discussion on the importance of ‘gesture’ when performing Japanese percussion repertoire. I gained insights I might otherwise not have had, and while this may seem a trivial example, it was one of many such encounters which adds so much to the overall experience of attending conferences, seminars, and workshops in person. Through attending these events I have since hosted and arranged performance opportunities for friends from abroad and visited friends and their families when travelling abroad myself. These cultural and personal connections influence our playing as musicians and further support the social context of music making.

Furthermore, by becoming completely immersed in the face-to-face learning environment while attending face-to-face events, I have found that I have had time to process thoughts and pause for reflection, including during the travel time following the event. In the online environment, there is often an abrupt transition back to the home environment, and it easy to quickly switch tasks to domestic matters without having pause for reflection on the learning that has occurred.

In my experience of attending face-to-face events originally initiated through online groups, the aim of online learning for this self-selecting group of students is preparation for 'real world' performing. However, for many others, it may be simply the enjoyment of learning an instrument without the pressure of performing in front of others. Thus, online musical communities can offer a wide range of opportunities to learners. These range from simply observing lessons online, to interacting with other musicians by sharing audio and video recordings online and can ultimately lead to many new creative and performing opportunities including learning, rehearsing and performing with other musicians in the face-to-face environment.

### 5.5.3 Music MOOCs

Music courses are offered on a variety of platforms such as Coursera and FutureLearn, with subjects including music theory, composition, song writing, improvisation, music technology and production, as well as instrumental courses in a variety of instruments, including guitar and piano. I have participated in many different MOOCs, partly as an observer, but also to boost my own learning and skills. These have included Berklee College of Music's 'Jazz improvisation' and 'How to play guitar' courses via the Coursera platform, and 'Learn Jazz Piano' on the FutureLearn platform (part of the Open University).

Many of these MOOCs follow a similar format of having content arranged in weekly sections, including videos, PDFs and backing tracks to download, and assignments to complete. The assignments usually take the form of student recordings which are then uploaded to a site such as 'SoundCloud' for peer review.

My experience in participating in MOOCs was generally positive. Materials were mostly well presented with the web content easy to navigate. I was able to draw on my experience of MOOCs when creating my own asynchronous online resources for teaching in immediately following the first lockdown and try and model good practice in making resources easy to navigate. In the

MOOC model, the high volume of students participating are used to give feedback, with teachers used only as expert lecturers, rather than interactively to give individualised expert feedback. Thus, students did not usually get guidance from a qualified teacher on instrument-specific technical questions. Students would pose questions such as: ‘how do I stop the strings buzzing when I play a barre chord on guitar?’, or ‘how do I play an open voicing chord with my left hand on piano if my hand won’t stretch that far?’. Moderators and tutors would occasionally comment, but most of the advice was from fellow students, and the quality of advice varied widely.

Another criticism I have is the pacing of the courses. For one of the courses I participated in, even experienced musicians found it difficult to keep up with the volume and pace of work, with many participants not submitting assignments at the suggested times, instead preferring to work through the materials in their own time.

Nonetheless, based on my experience outlined above, I believe that MOOCs have their place in the education ecosystem. MOOCs provide opportunities for participants to gain new skills in an accessible way, and very often at little or no expense. When used in conjunction with synchronous methods, such as webinars, videoconferencing, or face-to-face lessons, they become a powerful tool. Students could watch videos explaining technical aspects and review sections as often as needed and then move on at their own pace, with review in the synchronous lesson.

## 5.6 Discussion

### 5.6.1 Introduction

Videoconferencing has opened up the possibility of lessons to learners who may not otherwise be able to receive instruction due to a variety of factors including geographical location (Duffy and Healey, 2017), social circumstances, or more recently, social distancing due to COVID-19. In my own experience, having pipe band drum lessons, vibraphone lessons and piano lessons via videoconferencing was far more sustainable than travelling

to face-to-face lessons, as I was able to incorporate lessons as part of my weekly routine and family responsibilities without the cost and time spent travelling to and from a lesson. I was also able to continue teaching private students via videoconferencing when I relocated.

Musicians who are geographically or socially distanced from teachers may turn to the Internet when looking for resources. From there, they may find a wide range of informal learning resources, including YouTube videos, and also online communities of musicians with similar interests to themselves. This in turn can lead to 'real world' participation in music workshops, jam sessions and performances (Ward, 2019). This aligns with my own experience, and through participation in online lessons and online music communities, I have taken part in face-to-face music workshops and performances in the UK and Europe. MOOCs offer a structured approach to learning and may also offer opportunities for learners to interact with each other online.

### 5.6.2 Research question 1: What changes in the quality of the interactions and the learning and teaching experience in lessons between face-to-face and standard videoconferencing environments?

From my autoethnographic studies, I found that the learning and teaching experience changed between face-to-face and online environments due to network and audio issues, issues of building trust and rapport between teachers and younger students, not being physically present, not being able to play together with teachers and students, the importance of the visual element, and the importance of including parents as valuable helpers.

Participant H commented that the sound of the vibraphone from my studio could be distorted, but this was not an issue when I used the MalletKAT MIDI mallet keyboard. Parent S also commented on the audio quality form the electronic drum kit not being clear and distinct. This appeared to have improved when using the MS Teams platforms with students two years later, though there is anecdotal evidence that one of the variables of stability of

network connection included the Internet Service Provider, with some ISPs being notorious for having poor connections and audio quality on videoconferencing calls. Additional equipment such as better-quality microphones, audio interfaces, multi-camera setups and larger screens may have improved the experience to a certain extent. However, I feel it may have complicated matters in domestic settings unless, there was a parent present with technical expertise.

The quality of network connection could at times be problematic, especially with some of my earlier experiences with learning and teaching. The picture would sometimes freeze, and if the problem persisted, we would reconnect and sometimes opt for audio-only to give a more stable connection. For example, on one occasion after reconnecting many times with Participant H, we eventually decided to abandon the session and reschedule. The ease of connectivity, particularly when using Zoom with Students Q and R, was also another factor which led to some frustration. This settled down as the students became used to logging in with Zoom but having a responsible adult or an older sibling on hand to set up the equipment was very helpful. Based on my experience, my view is that the stability and quality of the network is the most important technical element in videoconferencing lessons, as a poor connection adversely affects the flow of the lesson.

In a blog post from January 2021, piano teacher Rebekah Maxner (2021) writes: ‘By now, most piano teachers have taught online, but how many of our students began with us in person. How challenging is it to begin piano lessons with a very young child?’. I asked Parent S for their views on whether it is appropriate to begin younger students online. They felt that in their situation, the nine-year old had coped with using the technology with some parental help when needed. We agreed that it was helpful to have had prior face-to-face contact, even if only to build some rapport, but that it could be possible to do this online. Parent S agreed that establishing a good relationship and rapport is essential in any teaching situation. This is perhaps even more important in distance learning, especially when there is no visual element and non-verbal cues cannot be read.

Maxner (2021) acknowledges some of the challenges of teaching younger students even in a face-to-face environment, including giving younger students meaningful learning experiences, and capturing and then maintaining their attention. Maxner goes on to emphasise the importance of involving parents in the lessons as an active on-site helper as in addition to helping to set up the videoconferencing equipment, parents can also help to make homework notes; find and turn pages in the lesson; point to particular places in the score to help the child focus; help by counting aloud, if the latency prevents the teacher from doing so; and if the parent has some piano skills, play the teacher's duet part (ibid.). This aligned with my own experience as I found it invaluable to have the parents on hand to assist with the technology, especially in the early stage of lessons.

Maxner (2021) further suggests that due to not being physically co-present with younger students, poor postural habits that are difficult to detect may develop. This point was echoed by a Teacher P (Study 2, Section 4.3.11). Maxner goes on to state that the biggest challenge teachers face with online lessons is 'developing tension-free technique in our youngest beginners. In person, a quick wrist check, elbow or arm check is only an arm's length away. Online, even with parent helpers, there's no easy replacement for this guiding hands-on approach' (ibid.).

I raised the question with Parent S of how important the visual element was when teaching remotely. We agreed that it is possible to teach without the visual element, but it does require very clear instructions, and teachers need to adapt their teaching style accordingly. I noticed a big difference in teaching between audio-only videoconferencing lessons and lessons where the video element was present, as I was able to check posture, stick grips and positions. In face-to-face lessons I could also easily check additional details such as how the drum kit was set up, and whether students could clearly see their music stand. It was also helpful for students to be able to see me when playing, even if only with peripheral vision.

### 5.6.3 Research question 2: Are some elements of music instruction more or less effective in face-to-face and standard videoconferencing environments?

Based on my experience from the autoethnographic studies, my view is that the MOOC model could be usefully adapted to supplement synchronous lessons, whether face-to-face, or via videoconferencing or low-latency technology in a blended model; face-to-face lessons facilitated teachers and students being able to clearly hear and see each other, and adjustment of musical equipment; playing together was an important element of the face-to-face lesson and while this can be partly overcome by use of backing tracks, students should still arrange to play with others.

Participant H remarked that it would be useful to have materials available on a website for easy access, and I found this to be the case when studying via MOOCs. I subsequently used this method with beginner drum kit students Q and R using Evernote, and then later with school students using the MS Teams platforms with the shift to online teaching from March 2020. However, despite having resources uploaded and easy to find in one place, there is no guarantee that students will actually look at resources between lessons, or have materials printed off and ready to use in the videoconferencing lesson. I therefore prepared PowerPoint slideshows for screen sharing during lessons to ensure that students were looking at exactly the section I wanted them to view.

I discussed the concept of hybrid learning with Parent S: having a mixture of face-to-face contact and maximising the time playing and rehearsing together, combined with videoconferencing lessons for some technical aspects and supporting skills such as music theory and aural skills training, and also the convenience of having asynchronous resources in one easy to find online location. We both felt that this is a potential way forward for instrumental teaching, in that it maximises the advantages of each learning environment, and also ensures that students have opportunities to play together with their teacher.

It was useful being able to make a direct comparison between teaching Students Q and R in face-to-face and videoconferencing lessons. The main advantage to the videoconferencing lessons was the convenience of neither myself nor the students having to travel, and this allowed the lessons to proceed as normal even during heavy snowfall. Both myself and the students found the face-to-face environment improved the experience of the lesson when compared to the audio-only videoconferencing lessons as we could clearly hear and see each other, I could easily adjust musical equipment, and it was possible to play together.

I have found playing together to be a very important element of the face-to-face lessons, and I found it limiting and frustrating not being able to accompany Students Q and R on piano, play together with them on drum kit, or to start and stop backing tracks from my own studio in the videoconferencing lessons.

However, in my experience as a learner, I have adapted to not being able to play together with a teacher in jazz lessons by having the iRealPro app ready to play with a backing track that facilitates easy looping of sections of a piece, as well as changing tempo and changing key. While teachers and learners can adapt to not playing together, there is a danger that in so doing, musicians end up losing a fundamentally important element of learning to play an instrument: live interaction with a more experienced musician.

### 5.6.4 Research question 3: What are the barriers to using videoconferencing in educational settings, and how can these be overcome?

Barriers to using videoconferencing mostly related to technological problems and attitudes from students and teachers towards technology. Brudvik (2018) suggests there are four main factors that prevent new music technologies being adopted in schools: expense, accessibility, attitude and usability. If a teacher or a student's first impression of the technology is negative, this will affect their attitude to using the technology. If a teacher or student is unable to

use the product through lack of knowledge or technical support, this will also affect their attitude. Another factor not mentioned by Brudvik is reliability. If a technology is not reliable, users quickly lose interest.

Videoconferencing had not been used by my Local Authority music service prior to the COVID-19 lockdown of March 2020. However, due to the success of videoconferencing during the lockdowns of 2020 and 2021, it has now become accepted as a means of delivering instrumental music lessons, including in December 2020 during a 'snow day' when I was unable to travel to school due to road closures, but I was able to teach remotely from my home studio. Students who were unable to attend the school had lessons in their homes, and those that were able to attend the school had lessons in their normal music classroom. In other instances, students who were self-isolating at home were able to participate in the lessons whilst I delivered a lesson in school in the face-to-face environment with the rest of their group. Other practices that are now more widely accepted include the sharing of performance videos between teachers and students, and the development of digital resources to support students in between lessons.

The sudden shift to online teaching during the COVID-19 lockdown has begun to reshape how schools consider the use of technology, and perceptions and attitudes have now changed. However, there is still a presumption that face-to-lessons are the best environment. While that may currently be the case for many aspects of instrumental lessons, the online environment and the advent of low-latency technologies bring many benefits, including ease of accessibility, and I believe these elements will increasingly be used alongside face-to-face teaching. This aligns with Daubney and Fautley (2020) who describe music teachers continuing to teach groups and individuals using a combination of online resources, recordings, and videoconferencing.

### 5.6.5 Final reflections

Despite the difficulties of videoconferencing described in this chapter, my experience is that students in the trials had a successful learning experience.

Participant H accomplished their goal and performed as part of an ensemble at a major music festival. I attribute a large part of their success to the participant's positive attitude, and their motivation in overcoming the technical and pedagogical challenges of learning via videoconferencing. Students Q and R also made excellent progress, but again, this may be partly attributed to coming from a musical family with very supportive and encouraging parents. Most school students who I taught via videoconferencing during lockdowns appeared happy with the remote lessons, though there was a preference for face-to-face lessons due to being able to play together, and also so they could see my movements easily.

My experience over the past ten years is that videoconferencing technology and network connections have improved considerably. However, the issue of equity of access for students is of major concern. It is recognised that not all households have either the musical equipment, the technology, or the space in which to support instrumental lessons at home (Daubney and Fautley, 2020) and this also aligns with my experience, in that not all students were able to, or wanted to, access lessons during lockdown.

Furthermore, there has been a shift in attitudes due to the necessity of moving to online methods of teaching during the pandemic. I had requested to trial online teaching in my Local Authority schools in 2017, but at that time, my request was declined by service managers. I feel this was a missed opportunity, as while the pandemic was difficult to predict or plan for, the music service could have been far better prepared for regular school closures such as 'snow days', and a fire had closed one of my schools causing huge disruption while lessons were held in alternative buildings. I therefore feel vindicated in choosing to pursue this research.

Moving forward, the current period of upheaval presents an opportunity for schools and higher education to build on improved digital skills, and to rethink the 'what, how and where' learning is delivered (Zhao, 2020). As reported by Azevedo et al. (2020) in Bubb and Jones (2020), the World Bank has called for building back 'more equitable and resilient post-COVID-19 education

systems that enable children to learn continuously both in schools and at home' (Bubb and Jones, 2020, p.220).

This chapter and the previous chapter support the case for videoconferencing and online resources being a valuable method for instrumental music teaching in a variety of contexts. However, despite the advantages described here, my view is firmly that good teaching is driven by the educator, rather than the method, technique, or technology employed.

This chapter has also established the importance of students playing together with a teacher in lessons and with other musicians in ensembles. The following chapter reports on my initial research into LoLa, a low-latency technology that facilitates playing together in lessons.

# Chapter 6: Initial LoLa trials

## 6.1 Introduction

This chapter reports the findings of my initial LoLa trials and is organised in seven sections: introduction; a report of a test of concept using LoLa in compression mode in a percussion lesson to determine the minimum bandwidth acceptable for teaching; a report of a trial in a jazz improvisation setting between the Royal Conservatoire of Scotland and Edinburgh Napier University; a report of a learning and teaching demonstration between the Royal Conservatoire of Scotland and Edinburgh Napier University with guitar students in front of an expert audience; observations of LoLa used for synchronous recording sessions between Edinburgh Napier University and the Royal College of Music, London, and Berklee College of Music, Boston, USA; an interview with Justin Trieger, the Director of Distance learning at New World Symphony, a world-leading orchestra training establishment; and a discussion section.

As discussed in Chapters 4 and 5, videoconferencing has opened up new possibilities for instrumental music learning and teaching, but the audio quality is often poor, and musicians are not able to play together. A major step forward in the development of audiovisual streaming came in 2005 when academics at the Conservatorio di Musica Giuseppe Tartini of Trieste, Italy, began developing LoLa (low-latency) software in response to the demand from musicians to be able to perform together remotely. LoLa is a software package that runs over a specialised network on an expressly specified Windows PC, with dedicated graphics and audio hardware and a camera with extremely low latency.

LoLa was further developed between 2008 and 2010 with the collaboration of Gruppo per l'Armonizzazione delle Reti della Ricerca (GARR), the consortium that leads the Italian National Research and Education Network (NREN) (Drioli et al., 2013). The first public demonstration of LoLa took place in November 2010 as a piano duo performance, with one performer in Trieste,

and the other in the Institut de Recherche et Coordination Acoustique/Musique (IRCAM) in Paris—a distance of approximately 1,300 kilometres apart (ibid.). In addition to music, LoLa can be successfully used in other performance contexts such as dance and theatre, as well as wider applications such as medical training (Ubik et al., 2016).

LoLa requires a fast high-capacity NREN such as GARR in Italy, or the Joint Academic Network (Janet) in the UK. This may not be a problem for well-established and sizeable academic institutions that are likely to already be connected to such a network, but it represents a major infrastructural challenge for more isolated communities and individuals (Redman, 2020). The success of LoLa also depends on a variety of additional factors, such as the network bandwidth limitations of the participating institutions, and the availability within those institutions of support from network engineers, sound engineers and technical staff (Davies, 2015).

The burden on resources of these additional factors can prevent institutions adopting the technology. An early trial in 2014 between the Royal Conservatoire of Scotland (RCS) and Edinburgh Napier University resulted in most of the RCS's 1 Gb bandwidth being used when LoLa was set to high-definition mode, which almost caused the network to crash. For that reason, RCS decided not to proceed with any further trials of LoLa at that stage. However, since that early trial, the LoLa software was further developed and made available with compression mode, taking only a fraction of the bandwidth previously required and making it more realistic for use in institutions.

Most institutions have two devices that separate the NREN from a locally connected PC: a Border Gateway Protocol router (BGP), which guides routing between autonomous systems on the Internet, and a firewall, a security device that filters traffic and blocks outsiders from gaining unauthorised access to the institution network. Due to the high volume of traffic generated by LoLa, network engineers are required to guide the network traffic to and

from the LoLa machine, successfully bypassing the firewall, whilst ensuring the rest of the institution's network remains safe.

Three different connection routes for traffic to and from a PC and an NREN are shown in Figure 1 below. At the time of the trials reported in this chapter, the RCS had an integrated BGP and firewall, which led to the unexpected finding that LoLa worked in conjunction with the combined BGP and firewall. This is discussed in Section 6.3. The first route shows the standard connection via a BGP and a firewall. The second route shows the suggested connection for a LoLa-enabled PC, bypassing the firewall and going from the BGP to the NREN; the third route shows the connection the RCS LoLa PC took, going through the combined BGP and firewall.

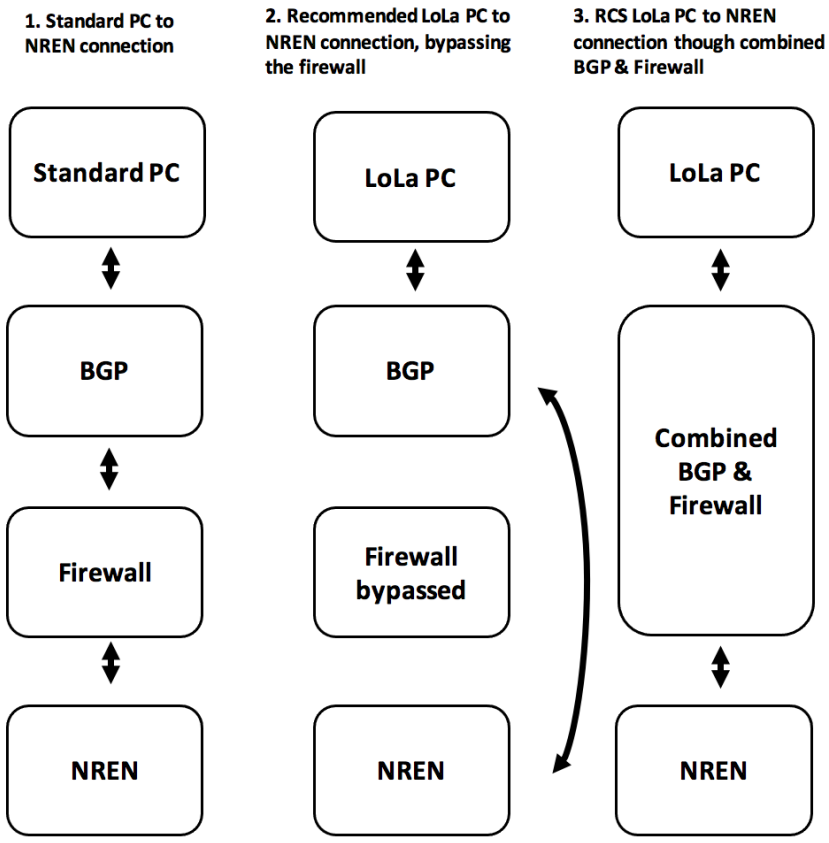


*Figure 1: Diagram showing PC network configurations for a standard PC connection, the recommended LoLa PC connection bypassing the firewall, and the configuration at RCS through combined BGP and firewall*

Presence refers to the degree of comfort users experience in a virtual environment. Presence is an emerging field of research that seeks to understand the experience of 'being', and how technologies can develop the improved sense of being co-present with others while physically separate, such as in Virtual Reality (VR) or Augmented Reality (AR) environments (Ruffini, 2009).

The central concept is that reality is constructed from sensory inputs, and that by adjusting the 'sensorial data stream' (Ruffini, 2009, p.12), participants can alter their subjective view of reality. My view is that LoLa may help to improve the sense of presence for participants in remote lessons by having a more stable platform, with better audio quality and low latency, where participants could play together in real time.

## 6.2 Study 9: Test of concept: LoLa in compression mode at Edinburgh Napier University

### 6.2.1 Introduction

The first trial was conducted in November 2016 in the music department of Edinburgh Napier University. The trial participants consisted of myself in the teacher role, an adult percussion student (Participant H) whom I had previously taught marimba using the Skype platform (Study 6, Section 5.3), with the technical arrangements overseen by Dr Paul Ferguson, Associate Professor of Audio Engineering at Edinburgh Napier University. Different studios were used within the music department for ease of access by Dr Ferguson for adjusting settings on each LoLa PC.

The specific research questions guiding the trial were:

- Investigate how the various settings of LoLa be adjusted to achieve an acceptable musical experience during a lesson.
- What is the minimum bandwidth required to achieve an acceptable musical experience?
- For sound quality in a lesson, how good is 'good enough'?

I chose to perform duets on snare drum with Participant H due to the snare drum's clear 'ictus' or attack, which allowed us to assess how successful our rhythmic timing would be when playing interlocking rhythmic patterns via LoLa.

The settings tested were frames per second (FPS), camera image size, packet size, and compression, with 40% being the maximum compression available, and 100% being no compression. Various permutations of these settings were tested: adding compression degrades the synchronisation between audio and video, and a lower FPS rate adds more latency between frames. A buffer was added to simulate distance on the network. Another consideration was that download and upload speeds on a network may not be symmetrical and need to be taken account of when assessing network capacity.

| Test no. | FPS | Comp. % | Picture size | Est. Mbps | Audio buffer | Latency in ms | Participant comments |
|---|---|---|---|---|---|---|---|
| **1** | 60 | 100 | 1280/720 RGB24 | 500 | 0 | NR | The system worked well. The volume of the other snare was initially lower, so the participants did not feel 'together' in the 'virtual' room; the volume was easily adjusted. |
| **2** | 50 | 100 | 1280/720 RGB24 | 500 | NR | 7 ms | A tiny delay was preferred to having minimum latency. |
| **3** | 25 | 100 | 1280/720 RGB24 | 500 | NR | 17 ms | Participants aware of an echo, though the audio and video were now synchronised. |
| **4** | 25 | 100 | 1280/720 RGB24 | 500 | 40 | 28 ms | Participants reported 'slap back' echo. |
| **5** | 50 | 100 | 1280/720 RGB24 | NR | 20 | 14 ms | Acceptable. |
| **6** | 30 | 100 | 640/480 | 86 | 10 | 7 ms | Acceptable. |
| **7** | 30 | 40 | 640/480 | 10 | 10 | 7 ms | System crashed and needed to be restarted. |
| **8** | 30 | 60 | 640/480 | 18 | 10 | 7 ms | Video good and in sync with audio; slight latency but acceptable. |
| **9** | 30 | 100 | 640/480 | 18 | 10 | 7 ms | Picture adequate, though soft focus and missing detail. |

*Table 5: LoLa settings for Study 9*

The results were noted and tabulated, see Table 5 above. Occasionally, data were not recorded as some tests were quickly abandoned before moving on to the next test; this is shown in the table as 'NR'.

### 6.2.2 Findings

The purpose of the trial was to explore the various settings of LoLa to achieve an acceptable musical experience in a lesson with 'good enough' sound quality using the minimum bandwidth possible.

At 30 FPS, 60% compression and picture size of 640/480 (being one quarter of a full screen), the audio and video quality were acceptable for synchronous interaction and required only 18 megabits per second (Mbps) bandwidth, well within acceptable limits for an institution with 1 Gb network capacity. Despite using compression mode, the audio quality was high, although this could be partly accounted for by using studio-quality microphones as opposed to the built-in microphones and speakers on laptops. The video quality was clear, there were no network issues, and the overall experience was superior to lessons via Skype.

In a duet setting, musicians should be listening and responding to each other. With a small amount of latency, typically between 8 to 25 ms, musical interaction is natural and relatively easy (Chafe et al., 2010). However, introducing additional latency in the range of 25 to 60 ms can quickly lead to a degradation of tempo as each player adjusts to the other's delay. Beyond this, there is a sharp decrease in 'playability' as the delays compound into a recursive feedback loop, quickly leading to a performance breaking down (Chafe et al., 2010). Thus, as latency was artificially increased, there was a greater need for myself as the 'leader' to maintain a steady tempo without being put off by hearing the delayed response from Participant H.

I found the experience of using LoLa to be vastly superior to using Skype. The audio was excellent and there were no disruptions in the network. I found playing together to be enjoyable, and the lesson felt much closer to that of a

face-to-face lesson with an improved sense of presence. However, the excellent audio quality was partly attributable to using studio-quality microphones and headphones under the expert supervision of Dr Ferguson, and LoLa was being run over the university's internal network with no noticeable disruption.

Participant H commented on the experience of using LoLa compared to Skype:

> The technical side was much better, as in the sound and video were so much better, that's obviously the clearest thing. I was really surprised at how easy it was […] and from a teaching perspective […] it's about as good as you'll get in terms of playing with the student.

### 6.2.3 Summary

The results demonstrated that LoLa could be used in compression mode with acceptable audio and video quality at a bandwidth of just 18 Mbps, much less than an earlier trial from 2014 which pushed the RCS network to near its 1Gb capacity. From this, a further trial between RCS and Edinburgh Napier was given institutional approval at RCS.

## 6.3 Study 10: LoLa trial between the Royal Conservatoire of Scotland and Edinburgh Napier University

### 6.3.1 Introduction

The second trial took place in September 2017. The aims of the trial were to check the minimum bandwidth required to successfully allow synchronous real-time musical collaboration via LoLa between remote locations, and to experiment with different permutations of LoLa settings to determine the importance of the synchronisation between audio and video for users. The trial also responded to my main research questions: investigating changes in the experience between the different environments, which elements of

instruction are best suited to these environments, and barriers to adopting the technologies in education settings.

The trial was conducted with myself playing vibraphone at the RCS in Glasgow, and a saxophonist at Edinburgh Napier University (Participant T), approximately 45 miles apart. We played a selection of tunes in a jazz idiom requiring improvised real-time interaction between the players. The results were recorded and tabulated, see Table 6 below.

### 6.3.2 Findings

The same four parameters as in the Edinburgh Napier University trial were tested in various configurations, with FPS ranging between 25 FPS and 50 FPS; compression ranging between 40% and 80%; packet size from 1000 to

| Test no. | FPS | Comp. % | Picture size | Packet size | Mbps | Comments |
|---|---|---|---|---|---|---|
| **1** | 25 | 60 | 1280/720 RGB24 | 1000 | 16 | The system worked well. |
| **2** | 50 | 60 | 1280/720 RGB24 | 1000 | 33.53 | The system worked well with better communication than test 1. |
| **3** | 25 | 40 | 1280/720 RGB24 | 1000 | 11 | Too much lag in audio and video, a problem if visual cues required. |
| **4** | 50 | 40 | 1280/720 RGB24 | 1000 | NR | Picture quality too 'jumpy'. |
| **5** | 50 | 60 | 1280/720 RGB24 | 1400 | 33.53 | Zero dropped packets. Quite a lot of audio artefacts: clicks and pops. |
| **6** | 50 | 60 | 1280/720 RGB24 | 1200 | 33.53 | Acceptable quality, though the compression made the experience feel 'not quite in the same room'. |
| **7** | 50 | 60 | 1280/720 Mono 8 | 1200 | 54.64 | Picture quality diminished: less colour depth, more washed out. |
| **8** | 60 | 80 | 1280/720 RGB24 | 1200 | 53.64 | Audio artefacts were distracting for the musicians. There was a lag between the audio and the video, resulting in a slight feeling of disconnect. |
| **9** | 40 | 80 | 1280/720 RGB24 | 1200 | 35.76 | Less emphasis on the video and more emphasis on the audio. Concern about the audio artefacts and the possibility of tempo degradation. |
| **10** | 50 | 60 | 1024/768 RGB24 | 1200 | 28.61 | Lots of audio drops. |
| **11** | 50 | 60 | 1024/768 RGB24 | 1000 | 28.61 | Very little audio degradation. |
| **12** | 50 | 60 | 640/480 RGB24 | 1000 | 11.18 | Acceptable quality overall, but video image smaller. |
| **13** | 50 | 65 | 1024/768 RGB24 | 1000 | 30.99 | The system worked well. |

*Table 6: LoLa settings for Study 10*

1200; picture size from the smallest at 640/480 RGB24 to high resolution at 1280/720 RGB24. No artificial buffer was required as the trial was operating over distance. Compression mode reduces the video image quality and introduces approximately 5 ms of additional latency. With maximum compression (40% quality), problems with lag between the audio and visual elements were noted, and the picture quality was also noted as being 'jumpy'. Audio artefacts manifesting as clicks and pops were noted at packet sizes above 1000 which became distracting.

Participant T commented, 'as a super-fast Skype, it is great, but the pops were more apparent and distracting when there's constant playing'. Participant T also noted that the compression mode made them feel 'not quite in the same room', whereas I felt very comfortable. A possible explanation for this lies in experiential differences. Participant T had recently used LoLa without compression mode in extended recording sessions (Section 6.5), which perhaps made using LoLa in compression mode feel compromised. By contrast, my experience up to that time had been mostly using the Skype and Facetime platforms, except for my one experience of using LoLa during the previous trial. Therefore, I found the superior audiovisual quality of LoLa, even in compression mode, resulted in a much more comfortable and natural feeling during the session than I was used to when using a standard videoconferencing platform.

An email sent from the developers at GARR to LoLa users in February 2021, stated that a firewall should either be bypassed or not installed: 'At the moment there are no firewall models (including the most powerful and expensive ones) which are able to correctly stand and handle the LoLa traffic'. An unexpected and significant finding from this trial was the discovery that the data had been routed through the combined RCS firewall and BGP, something that the LoLa developers maintain is not possible. Thus, we inadvertently demonstrated that LoLa can operate in conjunction with a network firewall, albeit with audio artefacts which manifested as pops and clicks. This finding is significant because many institutions have concerns

about connecting a device to the network that is not securely protected by a firewall, and this concern may prevent them from adopting LoLa technology.

### 6.3.3 Summary

The results from this trial demonstrated that LoLa can be successfully used with acceptable audio and video quality for teaching with bandwidth requirements as low as 16 Mbps, slightly less than the first trial. The best user experience would be achieved with no compression, a high frame rate and a large picture size. However, in Test 2 (see Table 6), a setting of 50 FPS, compression at 60%, packet size of 1000, and picture size of 1280/720 RGB24 allowed for successful synchronous real-time musical interaction, with an estimated bandwidth requirement of 33.53 Mbps.

Both Participant T and I found the musical experience using LoLa to be superior to that of standard videoconferencing. There was better audio and video quality and better network stability. This facilitated performing together and improved the sense of presence. We agreed that the more the audio and video elements were in synchronisation, the more likely they were to be used for visual cues, and this added to the sense of presence.

It is worth noting that the second trial between RCS and Edinburgh Napier University required the support of an IT specialist and a network engineer at RCS, and we also had a Skype connection to Dr Paul Ferguson at Edinburgh Napier to assist in connecting with the LoLa software. The LoLa interface is relatively easy to use, but it was helpful to have an expert on hand to advise on setting up the equipment and the software. Setting up the equipment took far longer than for a standard videoconferencing lesson, though the time would decrease as we became more familiar with the technology.

Following this trial, the RCS agreed to purchase the equipment required to use the LoLa software program, which included a PC with dedicated graphics and sound cards, and various other peripherals including a specialist camera. There was a long delay between receiving the equipment at RCS and

installing the LoLa software and testing the equipment, and it was during this time that we inadvertently discovered that LoLa had earlier been run in conjunction with the RCS network firewall. Eventually, LoLa was introduced to staff at RCS at the start of the 2019 academic year as part of a Learning and Teaching Conference, and this is reported in the next section.

## 6.4 Study 11: Learning and teaching demonstration using LoLa between the Royal Conservatoire of Scotland and Edinburgh Napier University

### 6.4.1 Introduction

The aim of the study was to trial the newly acquired LoLa system at RCS with teachers and students who had not previously used LoLa, and to get participants and audience feedback on its use. The LoLa system was presented to expert instrumental and vocal teachers at RCS in two separate 80-minute presentations as part of the annual RCS Learning and Teaching Conference in September 2019. This took the form of a demonstration of guitar lessons delivered via LoLa by the Head of Guitar and Harp at RCS (Teacher U), with two individual guitar students at Edinburgh Napier University. This was followed by a discussion between audience members at RCS, and staff and students at Edinburgh Napier, also via LoLa.

The demonstration was somewhat of an experiment; it was my first experience of setting up the equipment without the direct supervision of Dr Ferguson, and I needed some technical assistance at RCS with connecting the system to peripheral devices. Teacher U was experienced in using different platforms for virtual teaching, but it was their first time using LoLa, let alone in front of an audience, and to add to the novelty, they had not met the students previously. It was with some considerable relief on my part that the LoLa connection worked well and the lessons ran smoothly.

### 6.4.2 Lessons

The first lesson lasted approximately 15 minutes. Student V performed *Capricho Catalán* by Albéniz. The teacher listened to the student perform part of the piece and then discussed various elements:

- Technical: rolled chords; right hand fingering patterns; playing on different parts of the string to create colour; vibrato; how to avoid buzzing strings.
- Musical and interpretative: differences between score editions; balancing the tone quality of open strings; sustaining different notes; use of accelerando; different tone colours, from dry to warm; including dynamics along with tempo to aid phrasing and interpretation.

The second guitar lesson lasted approximately 20 minutes. Student W performed *Prelude No. 5* by Villa-Lobos. The teacher listened to the student perform the whole piece and then discussed various elements:

- Technical: judicious use of rolled chords; avoiding buzzing strings; right hand fingering patterns; moving right hand away from sound hole; left hand finger pressure.
- Musical and interpretative: bringing out different voices; dynamics and phrasing; interpreting the piece as being in either 6/4 or 3/4 time; use of tempo; alternate chord voicings; use of colouration, vibrato, and harmonics.

In both lessons, the technical and musical elements were first demonstrated or discussed by the teacher and then followed by interventions, including listening to the student repeating an element, playing along with the student, and giving commentary while the student performed.

### 6.4.3 Student and teacher experiences

Student V reported enjoying playing with the teacher in real time and being able to hear everything clearly. They acknowledged that LoLa was an important development for instrumental music teaching, and they were excited to see how the technology would develop in the coming years. Student W reported that it was their first experience of remote lessons, and despite taking several minutes to settle in, they had also enjoyed the experience.

Teacher U reported finding the LoLa platform an improvement on their previous experience with platforms such as eStaccato, a specialised commercial music instruction platform (since discontinued). eStaccato required users to wear headphones to prevent feedback, and the teacher preferred using loudspeakers rather than headphones when using LoLa. Teacher U reported that eStaccato also required an ethernet connection as opposed to Wi-Fi, and connections would often drop or freeze which necessitated rebooting computer systems.

Despite Teacher U's positive experience of using LoLa, they felt that the physical presence was missing, the tone was not the same through microphones and speakers, and they would have been able to go into more detail about some of the concepts discussed with the students. Thus, they would still prefer to deliver face-to-face lessons.

### 6.4.4 Audience discussion

The expert audience members noted that the audio quality on LoLa was clear and high quality, and they were impressed with how well the teacher had picked up on nuances of performance. Further discussions included how the audio input is affected by the microphone type, quality, and placement; the audio output is affected by the use of speakers or headphones; and the overall audio experience is affected by the acoustic properties of each studio. Another observation was that having an ambient hanging microphone would prevent a player's hands being obscured on the screen.

A vocal teacher with videoconferencing experience commented that when they taught face-to-face, they felt a singer's voice with their whole body, and they built up an 'imprint of representation' in their head of what a singer's voice sounded like. When working with singers remotely in a digital medium, they instead felt the voice as being 'two-dimensional', and they reacted with a kind of kinaesthetic memory sense of what was happening. They had concerns about auditioning students remotely as they felt they would not have an accurate representation of the quality of the student's voice. They also had concerns about losing the feeling of being present in the room with the student and not sensing their breathing or seeing their facial expressions on a micro-level.

There were various technical questions from audience members, including: could LoLa support video recording; what the minimum requirements were for running LoLa over a standard network; and was it possible to run multiple cameras and also trackable cameras, such as in the Polycom system. At the time of the demonstration in September 2019, it was possible to record the local end of a LoLa session, though it is anticipated that a facility will be developed for recording both sides simultaneously. Multiple-camera setups are now possible, and it may eventually be possible to use trackable cameras. A major consideration is operating LoLa over standard networks, and this is an ongoing area of development.

Audience members commented that they felt they would need technical support in setting up and using the technology, and that learning to work in this new medium would require developing a new skill set. There were also other practical issues to consider including booking the equipment and a studio, and it was noted that standard videoconferencing platforms could be used more flexibly in different studio locations without requiring a specialist network and technical support.

There was a discussion around LoLa having the potential to expand music education from a centre such as the RCS to local music hubs. This could include conducting ABRSM Scottish Traditional Music graded exams

remotely, and LoLa could also be used for auditions between institutions. There was interest in using LoLa for rehearsing remotely, for example, a string quartet based at RCS with some members in London.

### 6.4.5 Summary

The participants all reported positive experiences using LoLa. There was interest from the audience members in what was technically possible, and there was discussion about expanding the possibilities at RCS for rehearsing, teaching, examining, and auditioning using LoLa.

In both lessons, the students performed a short pre-prepared piece. Technical and musical elements were then discussed and demonstrated by the teacher, followed by listening to the student repeat a particular element. Crucially, the teacher was able to play at the same time as the students to assist with phrasing, timing, and articulation, and to give commentary during the performance. These elements were also observed in face-to-face lessons from my pilot study, showing that LoLa can more closely match the experience of face-to-face lessons than standard videoconferencing platforms.

## 6.5 Study 12: LoLa as a facilitator of remote synchronous recording

### 6.5.1 Introduction

I observed two sessions at Edinburgh Napier University using LoLa to facilitate remote synchronous recording. The first session took place in November 2016 with a saxophonist and a bass player in the Napier studio in Edinburgh, and a drummer in a studio at the Royal College of Music in London, a distance of approximately 400 miles. The second session took place in August 2017, with the same two musicians in Edinburgh, and a guitarist at Berklee College of Music in Boston, USA, a distance of over 3,000 miles.

Audio from each location was captured and then mixed using cloud-based features of Pro Tools, a professional recording software program. The video element was projected onto glass screens at each studio showing the remote musicians life-sized. The round-trip latency between Edinburgh and London was approximately 10 ms; however, the latency between Edinburgh and Boston was approximately 100 ms, above what is considered an acceptable latency threshold for musicians (Chafe et al., 2010).

### 6.5.2 Report from the recording sessions

Three tracks were successfully recorded during the first session between Edinburgh and London. Discussions were held amongst the band members as to who would count the band in, who was leading and who was following, and who would signal the end of solos via video.

The musicians reported taking some time to feel as though they were in the ‘same room’ together. It was reported in the Edinburgh studio that the drums occasionally dropped out for a beat or two, though the audio quality was mostly consistent. At 30 FPS the video was slightly behind the audio; at 60 FPS the video felt much smoother which was important for the musicians for giving visual cues. The network was being monitored and it was noted there were occasional ‘spikes’ resulting in lost packets of data.

Two tracks were successfully recorded during session two between Edinburgh and Boston. Discussions were held amongst the musicians about how to manage the increased latency. The latency in one direction of approximately 45 ms was doubled by the return of the audio in the other direction, with a few extra milliseconds added for peripheral connections, resulting in a roundtrip latency of approximately 100 ms. Initial attempts at playing together broke down musically due to the compound latency of the round trip resulting in a degradation of tempo; each party hearing the remote band members delayed also caused them to delay. It was decided that the guitarist in Boston should take the lead and they put the other band members on mute so they would not be distracted by hearing the remote band

members playing fractionally later than themselves. This aligned with findings from Chafe et al. (2010). Adding more rhythmic complexity to a piece tended to cause it to slow down, and thus some pieces worked more effectively than others in this environment.

There were occasional issues with audio artefacts such as ‘pops’, and the video element was considered important for cueing entries and anticipating changes in dynamics. The two musicians in the Edinburgh studio found it off-putting seeing each other just feet away, while listening to the audio from the guitar player with a degree of latency. Problems were noted due to a talkback microphone in the Boston studio causing a ‘slap back’ effect with a slight delay.

There was some discussion about whether the musicians in Edinburgh were in effect playing to a backing track, as the guitarist in Boston was leading and had muted the Edinburgh musicians. However, it was agreed that the procedure was far more efficient than playing to a backing track, as the musicians had the opportunity to discuss each ‘take’ and immediately re-record sections, rather than sending email correspondence and having to go to a studio to make further recordings. Furthermore, bodily movement and visual cues from the leading musician helped the other musicians, so the experience was very different to recording with a backing track.

### 6.5.3 Summary

The recording sessions demonstrated an applied use of LoLa in a very tangible and meaningful way for musicians in remote locations, including across continents. As expected, increasing the distance between the remote locations increased the latency. However, the musicians were able to interact in real time and successfully record together, especially in the first session between Edinburgh and London, and even at the greater distance between Edinburgh and Boston.

Despite the necessity of having a leader and follower at greater distances, the ease of social interaction between recording 'takes' made the LoLa experience superior to an asynchronous recording session.

The participants considered the video element to be important, and the closer in synchronisation the audio and video elements were, the more the video was used for giving and receiving visual cues.

## 6.6 Study 13: Interview with Justin Trieger, Director of Distance Learning and New Media at the New World Symphony Music School

### 6.6.1 Introduction

The aim of the study was to understand the history and background of distance learning, and possible future directions, at a world-leading music establishment from a leading authority in the field. I conducted an interview with Justin Trieger, the Director of Distance Learning and New Media at the New World Symphony Music School (NWS) in Miami, Florida, in December 2019. NWS is an American orchestra training establishment that has used different technologies to connect with national and international partners over a number of years. We discussed a wide range of issues relating to the use of technology for remote learning in music education. Trieger is recognised as a leading authority on distance learning and teaching and as such, he is one of two named participants in the thesis.

### 6.6.2 The use of different technologies

NWS had experimented with different technologies since 2002. The first was a hardware appliance designed by Star Valley Systems that hosted point-to-point calls. It was described as being 'very specialised, very expensive, and didn't work very well'. The next technology trialled circa 2006/2007 was a software application, Digital Video Transport System (DVTS), that facilitated point-to-point streaming of a DV camera on a Windows PC with no added latency. It was the first technology to offer uncompressed stereo audio with

high-fidelity and was considered essential for offering critical feedback to students. However, it had high levels of latency and no echo cancellation. This resulted in echo chambers and was prohibitive for teaching as users would ‘stumble over themselves’.

DVTS was followed by Microsoft Conference XP, another windows application where users could independently control the compression levels of both audio and video. This allowed the use of high-fidelity uncompressed audio using professional audio devices, paired with heavily compressed video. It also suffered from high latency due to being a software application using proprietary drivers and CPU-intensive compression.

The first low-latency technologies trialled were LoLa and UltraGrid, circa 2011. At that time, LoLa had black and white video in standard definition, but the audio was stereo and uncompressed, and easily facilitated playing together at distances of up to 1000 kilometres. NWS has a training programme bringing youth orchestra members together remotely from cities across the United States. This had previously been facilitated by running multiple LoLa sessions simultaneously, but it is now possible to directly connect three remote locations using LoLa 2.0.

Trieger described the rationale for using different types of technology:

> Institutionally, it’s our mantra that whatever works will work, and so we pick and choose our software for these types of activities just based on the context and circumstances of the partners involved, and also just what offers the most likely success in whatever the goal of the project or activity is that we are trying to achieve. If that’s teaching, LoLa is obviously great, just because of the immediacy of it. If that’s something more like where video is more important, where presentation is part of the game, then UltraGrid is equally interesting for us, because that offers the ability to stream high-resolution video, which LoLa currently does not. It’s not as fast as LoLa, I think the lowest latency in the software itself is about 80 milliseconds, but it can utilise both 4K and 8K video, using consumer devices and consumer computers, which is pretty impressive.

### 6.6.3 Playing together

Trieger went on to discuss how well LoLa compared with other audiovisual systems in terms of being able to play together:

> It still remains the only tool that really makes that possible. That's if your goal is to play in sync, and to play traditional classical repertoire or popular music repertoire. There are actually a lot of newer works being created where people incorporate the latency and delays involved in network connections as a creative device, but that's not really the game that we play most of the time. So, it's quite effective for playing in sync.

Trieger commented on the experience of playing together using LoLa:

> If you're in the percussion section and you're following a conductor who is a good 50–60 feet away, then latency at 45 milliseconds is something you're pretty used to […] so people are already used to playing with these latencies anyway, so it's just a kind of construct when you put people on TV and playback through speakers.

This aligns with my experience as an orchestral percussionist and working with a conductor some distance away and having to recalibrate my sense of timing when working with smaller ensembles.

Synchronisation between the parties was discussed:

> There are a couple of strategies people usually employ in the beginning which is to establish one side as the person who is establishing tempo and entrances, so a leader and a follower kind of situation. However, once people spend a little time with the platform and inherently begin to feel what the latency produces, it starts to feel much more like a chamber style performance, where people are waiting for each other to breathe, and they develop ways of cueing each other. So, it's much more give and take after that initial awkwardness period.

This aligns with my experience of the earlier LoLa trials (Sections 6.2 and 6.3), and also my observation of the studio recordings (Section 6.5).

### 6.6.4 Audio and video quality

The audio quality of LoLa is reported as being excellent:

> More recent versions can support up to 96 kilohertz (kHz) sampling rate which is better than CD quality audio. We don't typically use that, but a good default is CD quality stereo audio, so 44.1 kHz, 16 bit, which sounds as good as streaming audio you can find on any other kind of platform.

However, despite the excellent audio quality, it does not radiate sound in the same way an acoustic instrument in a face-to-face environment would: 'While it can sound very realistic and clear, it's not a true representation of what the instrument sounds like in the room. So that's another complaint people have'.

The video quality was reported as being inferior to the audio quality:

> The cameras you're required to use for the platform are not the best optically, just from a pure camera sensor standpoint. So, colour representation is a little funky, contrast is not exceptional. The lenses are pretty inexpensive zoom lenses, so the optics are not fantastic. The resolutions it offers are OK, I think 1920 by 1080 might be the highest resolution it goes. For our purposes it offers plenty of resolution, it looks good on a big screen, but it's actually just the limitations of the camera itself, and its ability to pick up light and colour. But it's not the biggest impediment in my opinion.

The LoLa developers have given preference to achieving the best quality audio at the expense of the video which makes LoLa more suitable for music interaction than UltraGrid, where the video is higher quality but with more latency.

### 6.6.5 The studio and virtual environment

We discussed various aspects of the studio and the virtual environment to help users gain a sense of presence and feel comfortable. Screen and camera placement were considered important to attempt to overcome the known problem of users not looking directly into the camera due to looking at

the other user on the screen. A solution was to mount the cameras directly on the television frame with a small angle of incidence between the camera and the screen. ‘LoLa cameras are actually small enough that you can place them in front of the display, and it doesn't obscure too much of the image […] but it's still a problem and remains a problem’.

In addition to screen and camera placement, camera framing was considered important, along with trying to maintain realistic proportions, preferably life-size: ‘that way it creates the sensation of looking through a window’. Matching the acoustic and physical appearance of environments helped to achieve a sense of unity and presence.

### 6.6.6 Stability and usability of the LoLa platform

Network stability was not an issue when using LoLa, unlike videoconferencing:

> If you're on a research and education network with no security measures in place, it is not usually a problem. I've never successfully done LoLa over a commercial internet service, partially because it does not work well with firewalls because of the rapid number of packets that it generates […] it’s kind of reserved for private networks or research and education networks at this time.

We also discussed the usability of LoLa and whether support was required for its operation. Trieger commented:

> The operation of the software itself is very simple. Assuming the network conditions are perfect, it's pretty easy for anyone to pick up and use without much technical support, the interface is very simple. The real challenge is in the initial deployment stages, convincing most IT departments to create the ideal network conditions for the software. Which, as I said before, means no security, no filtering of data, no data shaping, which are common security measures that university networks like to deploy, so they don't like turning them off!

This aligns with my experience in the earlier trial at RCS. I found the LoLa software was easy to use after receiving initial guidance, and with the LoLa

signal being routed through the combined BGP and firewall at RCS (Section 6.3), audio artefacts were present.

### 6.6.7 Pedagogical considerations

Physical limitations of music education in the LoLa environment were similar to those found from Studies 2 and 4–7 in the videoconferencing environment. The two most important elements were not being able to adjust instruments and posture.

Writing on the score was considered less important on the whole:

> Honestly, I don't know that score and writing on music comes up very often in our private lessons. It's not super common, so I think mostly it's just the ability to physically adjust people is the big one right now.

However, being able to write on a score may be important for some teachers in certain situations.

We discussed changes in teaching styles between the virtual and the face-to-face environment. One positive benefit was teachers being forced to verbalise their instruction a lot more, which caused them to think more critically about what they were saying, and how to communicate that in an effective way. The downside was that after about 45 minutes lessons became exhausting due to the hyper-focus and verbalisation required compared to the face-to-face environment.

The appropriateness of using distance learning technologies for different ages and stages of development was discussed:

> I think there are clearly times when physicality is more important than finesse. So, when you're just learning how to hold an instrument, or how to do a bow stroke, or how to hold sticks, or do things like paradiddles and all those drumming rudiments, that stuff is better taught in person simply because you need to be able to grab people's hands and move them, or do this very quick call and

> response, ‘follow what I'm doing, and then you do it’. But when technical skill is not what's mostly being addressed, when it's more interpretation and very high-level instrumental performance, the physical side is not so important. But you know, we use these tools with kids in secondary school, sometimes in middle schools, so I think it can work for people of any experience level. I think it's just that very beginning stage where you are learning how to hold the instrument is when it's not really ideal. That's not something you can really learn on video.

Trieger did not consider LoLa to be a replacement for face-to-face teaching: ‘I think there is always some kind of desire to be in the same room, regardless’.

### 6.6.8 Implications of the technology

We discussed implications for how students may learn in the future. There was a recognition that younger generations are increasingly learning skills online:

> This is an expectation that is being ingrained in people from a very young age, that they can access expertise and learn things over the Internet. And so better that universities and music teachers embrace that, than try to resist it […] It’s a threat to the old model simply in that it encourages exploring multiple viewpoints.

New technologies give students the possibility of learning with teachers anywhere in the world without necessarily enrolling at higher education institutions:

> In a conservatory […] people tend to get into a studio with a particular teacher and then learn that teacher’s method, and then that's how they form the basis of their musical playing from that point onward. But I don't think that's really how it's going to work anymore. I mean we've only seen adoption of these technologies increase; I've never seen a decrease reported anywhere, and as the technology becomes cheaper and the Internet gets better, I think the opportunity far outweighs any kind of negative repercussions we might see.

Students may choose to enrol at particular institutions so as to learn with particular teachers, but with the increasing use of technology to gain access to teachers, this model may be disrupted.

### 6.6.9 Future possibilities

Possible future directions of technology were discussed, including Virtual Reality, Augmented Reality, and wearable haptic technology:

> I think they have interesting implications for this kind of teaching environment we've been talking about, simply because it allows someone to assume the perspective of someone else, and so that's an interesting teaching mechanism. And also, the major shortcoming being that you can't physically manipulate someone else.

We discussed how in the future some universities may move from face-to-face, to online attendance:

> I think that we're in the beginning of this paradigm shift and it's going to be really interesting ten years from now to reflect on this conversation and see just how far things have gone. I wouldn't be surprised if there were some universities whose total attendance was virtual and had a very rewarding and fulfilling experience for the people who enrol.

These comments from December 2019 proved out to be prescient in light of the rapid shift to online learning just a few months later.

### 6.6.10 Summary

NWS uses the most appropriate technology to suit their circumstances. UltraGrid has higher quality video, and also uses less expensive consumer devices than LoLa, but LoLa is the only audiovisual tool available for playing synchronously, and it can operate audio at better-than CD quality.

The LoLa software is simple to use and has a simple interface. The biggest technical issues are normally network related, especially when working with

new partners who are not used to rerouting traffic around a firewall. The biggest challenge is the initial deployment stage, and convincing IT departments to create the best conditions for the software.

The studio environment is improved by attempting to make the monitor or projected display life-size if possible, so as to give the impression of looking through a window, and also trying to match the acoustics of the studio spaces. Despite the high-quality audio, users comment on the sound not giving a true representation of the other players. Players need a little time to get used to the latency, but they learn to adapt and develop ways to cue each other.

Pedagogical considerations include the physical limitations of adjusting instruments and posture. Writing on the score was considered less important, and not an issue for teachers at NWS. Lessons became less effective after approximately 45 minutes due to exhaustion from hyper-focus. Despite the advances in distance learning, there was still a preference for learning in person where possible, with online instruction used as a supplement.

It was acknowledged that younger generations are increasingly learning skills online and are used to accessing expertise via the Internet. It was predicted that we are at the start of a paradigm shift, with the adoption of technology increasing as costs decrease and the quality of the Internet improves. Some universities may move to having virtual attendance only, which may disrupt how teachers are hired in the future.

## 6.7 Discussion

### 6.7.1 Introduction

The results from the first two trials showed that LoLa can be used in compression mode giving an acceptable musical experience for teaching, with a modest bandwidth requirement of between 16 and 33 Mbps, making it acceptable for use within institutions with a 1 Gb network capacity. The second trial also suggests that developments in firewall technology may allow

LoLa to be used in conjunction with an institutional firewall, making it easier to use in an institution.

Participants from the two trials and the teaching demonstration reported positive experiences of using LoLa. The teaching trials showed that LoLa can more closely match the experience of face-to-face lessons than standard videoconferencing platforms. Crucially, teachers were able to play at the same time as students to assist with phrasing, timing, and articulation, and to give commentary during a student performance.

Participants in the trials reported the audio and video quality were superior to standard videoconferencing platforms, as was the network stability. This could partly be attributed to using better-quality microphones, larger monitors, and an institutional network as opposed to home Wi-Fi. Nevertheless, the experience was improved, and supported my earlier view that LoLa could give a superior experience compared to standard videoconferencing.

The recording sessions demonstrated an applied use of LoLa in a very tangible and meaningful way. The various settings were adjusted to try and give the optimum experience and the more the audio and video elements were in synchronisation, the more the video element was used for musical cues.

The UltraGrid platform has high-quality video and as discussed by Justin Trieger of New World Symphony, UltraGrid may be more suitable than LoLa for circumstances where the video element is preferred to the audio element such as theatre or dance. However, LoLa is currently the only audiovisual streaming tool available for playing music together with synchronised video.

### 6.7.2 Research question 1: What changes in the quality of the interactions and the learning and teaching experience in lessons between face-to-face, standard videoconferencing, and low-latency environments?

From the first trial, Participant H reported being surprised at how easy it was to play together in the lesson using LoLa and was impressed by the high quality of the platform. I found the experience of using LoLa to be vastly superior to using Skype as the audio quality was excellent, and I found playing together to be enjoyable and much closer to the experience of a face-to-face lesson.

From the second trial, Participant T found that using LoLa with compression applied was less comfortable than their experience of using LoLa during the recording sessions without compression (Section 6.5). A contributory factor to their discomfort may have been the audio artefacts present due to LoLa being routed through the combined BGP and firewall. My view is that for teaching purposes, using LoLa with compression gives a very acceptable experience; for recording or performing purposes, more bandwidth should be prioritised.

The amount of latency present when using LoLa was affected by the distance between remote locations, and also the settings on the software. The participants in the recording sessions adjusted for the greater latency between Edinburgh and Boston by adopting the leader and follower model. This allowed them to successfully record together and suggests that instrumental lessons could work on the LoLa platform even at great distance, provided participants adapt accordingly.

The studio environment was improved by using a large monitor or projecting an image display life-size so as to give the impression of looking through a window, and also trying to match the acoustics of the studio spaces.

Despite the technological advances and high-quality audio of LoLa, the guitar teacher noted a preference for learning in person, partly due to the sound

lacking the natural reverberation of a live performance. These comments aligned with the experience of Justin Trieger when working with staff and students at the New World Symphony.

### 6.7.3 Research question 2: Are some elements of music instruction more or less effective in these different environments?

The main advantage of LoLa compared to videoconferencing platforms is being able to play together. LoLa can currently connect three remote locations simultaneously, whereas standard videoconferencing platforms can connect multiple locations. As reported earlier, videoconferencing facilitates being able to record segments of a lesson and whereas this is possible using LoLa, the facility is still being developed.

From my previous chapters on videoconferencing, experiencing poor connectivity and switching to audio only had a detrimental effect on the experience for teachers and learners. The findings showed that when using LoLa for synchronous playing, the video element was important for giving visual cues and also for peripheral vision to improve the sense of co-presence for participants. It is possible to adjust how much the audio and video elements are synchronised using LoLa, and the more they were synchronised, the more the visual element was used.

Pedagogical considerations for working in all remote environments include the physical limitations of adjusting instruments and posture, especially in the beginning stages of learning. Writing on the score was not considered an important issue for teachers, and as in the learning and teaching demonstration (Section 6.4), teachers can discuss with students which edition of a score is being used in advance of a lesson.

Lessons were reported to be less effective after approximately 45 minutes due to exhaustion from hyper-focus. However, as teachers and students become more used to working in remote environments, and improvements in studio environments are made to improve the feeling of co-presence, then

participants may be able to sustain longer sessions and an increased number of sessions. This is an area for further investigation to ensure teachers do not become unwell as a result of remote working, as reported by teachers new to remote teaching in Chapter 4, Section 4.5.5.

### 6.7.4 Research question 3: What are the barriers to using these technologies in educational settings, and how can these be overcome?

Trieger reported that a major challenge for adopting LoLa in an institution is the initial setup stage and working with IT departments to create the best network conditions for deploying the technology. This aligned with my experience; in order to trial LoLa at RCS, I first needed to overcome the perception that the platform required a large bandwidth to operate. LoLa also needs the approval of an institution's network engineer in order to work with the firewall, additional storage facilities, and ongoing technical support from the IT department.

As reported by Brudvik (2018), expense is another factor that can prevent institutions adopting technologies. The initial outlay for the LoLa equipment may be prohibitive for some institutions such as schools, and careful consideration needs to be given as to whether the cost can be justified against the benefits the technology can bring. My view is that provided enough institutions adopt low-latency technologies, the opportunities for collaboration between institutions will bring a significant benefit.

The LoLa software has a simple interface and is relatively simple to use, but the trials required the support of an IT specialist, a network engineer, and in the initial stages, Dr Paul Ferguson who has expert knowledge of the LoLa system. Setting up the equipment also took far longer than for a standard videoconferencing lesson; this needs to be considered when planning lessons via LoLa. However, for masterclasses and regular scheduled lessons in conservatoires, this need not be an insurmountable issue.

### 6.7.5 Final reflections

Throughout the thesis, I have argued that being able to play together is an essential part of face-to-face instrumental music teaching. Students miss out on not being able to play with their teacher when using standard videoconferencing platforms, but as shown by the findings from this chapter, LoLa facilitates playing together. However, as reported by Justin Trieger, and later on in the thesis by Sarah Weaver (Chapter 8, Section 8.4), new music is being created that does not depend on maintaining a steady beat, and some musicians and composers incorporate the latency in network connections into their music (Rofe and Reuben, 2017). Thus, while low-latency audiovisual streaming is a welcome improvement over standard videoconferencing, it does not preclude musicians adapting how they work together and incorporating latency into their musical interactions, for example, as call and response.

The findings demonstrate that low-latency technology facilitates musical interactions that were not previously possible at a distance. This has the potential to change how students learn, and also how teachers and musicians work in the future. As discussed by Justin Trieger, younger generations are increasingly learning skills and accessing expertise via the Internet. Even prior to the pandemic, we were at the start of a paradigm shift; the adoption of technology is increasing as costs decrease and the quality of the Internet improves. The pandemic has accelerated these changes and some universities may move to having virtual attendance only, which may disrupt how teachers are hired, and how and where students choose to study.

This chapter has reported on small-scale teaching trials of LoLa and demonstrated the potential of LoLa in education. The next chapter reports on a larger-scale teaching trial using LoLa in three European conservatoires, in which technological and pedagogical aspects using different instruments are explored in greater detail.

# Chapter 7: Evaluating LoLa in European conservatoires: the SWING project

## 7.1 Study 14: Introduction

Chapter 6 demonstrated the effectiveness of LoLa in facilitating synchronous playing between teachers and students when working remotely, an element missing from standard videoconferencing lessons. The literature shows a need for further testing of LoLa in education settings (Davies, 2015; Riley et al., 2014).

This chapter addresses this gap by reporting on a larger-scale teaching trial using LoLa in three European conservatoires. The chapter is organised in three sections: introduction, in which the project is contextualised; findings, in which the six themes arising from the data are explored in detail; and a discussion section.

The Association Européenne des Conservatoires, Académies de Musique et Musikhochschulen (AEC) is a cultural and educational network representing the interests of Higher Music Education Institutions (HMEIs), with over 300 member institutions in 57 countries in Europe and beyond. The AEC provides support, information and expert advice to member institutions, and also engages in advocacy at European and international levels to raise standards of Higher Music Education (AEC, 2021). The Royal Conservatoire of Scotland (RCS) is an active member of the AEC and in January 2020, hosted a doctoral research colloquium on the topic of ‘low-latency streaming in music learning and teaching’, jointly organised by the AEC, the RCS, Learning and Teaching in Music Performance Education (LATIMPE) and the Centre for Excellence in Music Performance Education (CEMPE).

The AEC initiated the SWING project (Synergic Work Incoming New Goals for Higher Education Music Institutions), a strategic partnership project running from September 2018 until September 2021, funded by the European Commission's Erasmus+ programme. Erasmus+ is the EU's programme to

support education, training, youth and sport in Europe, including supporting students to study and train abroad (European Commission, 2020). The aims of the SWING project are to experiment with and then establish learning opportunities between different countries by deploying technologies such as LoLa, thus supplementing the physical movement of teachers and students between institutions with a virtual presence (AEC, 2019). The SWING Evaluation Concept is attached at Appendix E.

Trials of LoLa were conducted in three conservatoires located in Austria, Italy and Slovenia in early 2019. The conservatoires were chosen for their geographical proximity and existing links between the three institutions. The conservatoires were asked to select staff and students to participate in the teaching trials, which consisted of a series of lessons or a single lesson of approximately one hour in duration. The 17 participants included two teachers, two students and two technicians from each conservatoire (one technician from Austria). The teachers and students came from different instrumental categories including piano, voice, guitar, saxophone and accordion, shown in Table 7 below.

| Interview code | Country | Participant |
|---|---|---|
| A1 | Austria | Technician |
| A2 | | Piano teacher |
| A3 | | Guitar teacher |
| A4 | | Vocal student |
| A5 | | Saxophone student |
| It.1, It.2 | Italy | Accordion teacher and student |
| It.3, It.4 | | LoLa programmer and technician |
| It.5, It.6 | | Vocal teacher and student |
| S1 | Slovenia | Piano student |
| S2 | | Piano student |
| S3 | | Guitar teacher |
| S4 | | Piano teacher |
| S5 | | Technician |
| S6 | | Technician |

*Table 7: Study 14: SWING trial participants*

Following the trials, initial surveys were conducted with the 17 participants. A copy is attached at Appendix F. This survey was followed by semi-structured guided interviews later in 2019. The aim of the interviews was to understand each participant's expectations and experiences of using low-latency technology for instrumental music teaching, and to form an understanding of the potentials and limitations of using the technology in conservatoires.

My involvement with the project began when I discussed my research into low-latency technologies with Dr Stefan Gies, Chief Executive of the AEC in April 2019. My original intention was to build on the work of other researchers (Davies, 2015; Riley et al., 2014) and my earlier LoLa trials (Studies 9–11), and assess LoLa in a larger-scale teaching project, something that had not previously been done.

I had planned further trials between the Royal Conservatoire of Scotland, Edinburgh Napier University, and additional international partners using a variety of different instrument types. However, as discussed by King et al. (2019), an ideal experimental design is not always possible when dealing with the needs of participants in real world studies. It can be difficult to conduct research projects in conservatoires with busy teachers and students, and due to scheduling difficulties and competing demands on the institutional resources including infrastructure and staff, the planned trials did not take place. Levinsen et al. (2013) confirm the practical difficulties of setting up teaching trials, noting that they had designed three scenarios using videoconferencing, but for practical reasons, they were only able to realise one.

I subsequently made enquiries about observing and interviewing teachers and students at other institutions where LoLa was already being used. However, shortly after this, the AEC announced the implementation of the SWING project. The project closely aligned with my own goals in seeking to understand the experience of teachers and students in using LoLa technology for instrumental music teaching. Over a Skype call with Dr Gies of the AEC in April 2019, we discussed my research plans and how these might articulate

with those of the SWING project. I shared the interview prompts from my proposed earlier trials, and these contributed to the prompts used by the project team.

The SWING project participants were asked to consider and comment on the following issues which relate to the qualitative experience of using LoLa which my research questions are addressing:

- the pedagogical advantages and disadvantages of LoLa;
- the participants' personal experience of technology;
- how the various aspects of communication changed using LoLa;
- participants' perception and management of audio quality in face-to-face and LoLa settings;
- can LoLa enrich or replace the traditional lesson?

The interviews were conducted by three different researchers from the AEC with individual participants either face-to-face or by videoconferencing. The interviews in Slovenia were conducted in English; the interviews in Italy and Austria were conducted in their respective languages and interview transcripts were then translated into English. I was given privileged access to the raw interview transcripts in January 2020, which I then prepared for analysis.

I first identified broad 'a priori' themes from the research questions: technological issues, pedagogical issues, Erasmus + exchange, future developments; I then used inductive coding to allow new themes to arise from the data (King, 2016) and assigned codes to different parts of the text. These were then added to a hierarchical coding frame, grouped together into themes and summarised.

The following themes emerged:

- the rationale for using LoLa;
- pedagogical considerations;
- Erasmus+ exchange;

- the physical and virtual environment and instrument-specific issues;
- participants' attitudes and perceptions to using LoLa technology;
- possible future developments.

The SWING project was due to conclude by September 2021, but due to the pandemic, the project has been extended.

## 7.2 Findings

### 7.2.1 The rationale for using LoLa

Teachers, students and technicians from the trial commented: 'the great thing about LoLa is this lack of latency', and 'the delay wasn't a problem, it worked really well'. The main advantage reported of LoLa over other audiovisual streaming platforms, including Polycom and UltraGrid, was the high-quality, low-latency audio. A member of the LoLa development team (Participant It.3) was interviewed as part of the project and reported that high-quality audio is the factor most requested by musicians: 'Many musicians have stated a privileged interest in the sound experience over the visual experience'. The LoLa developer also commented on the video quality: 'Polycom and UltraGrid provide better 4K video performance, while LoLa only gets to Full HD. LoLa prioritises and ensures a shared sound experience in real time'.

LoLa can also be used for rehearsing and performing. The accordion student reported being interested in the opportunity of performing with other musicians remotely; two piano students expressed an interest in trying LoLa for chamber music lessons and rehearsals with students from other conservatoires, particularly if they are from different cultures and musical backgrounds so as to give a different and fresh perspective. A vocal student felt initial rehearsals could be useful via LoLa, but that face-to-face rehearsals were important for more in-depth work:

> For the fine work, it is certainly better if you see each other. There is also a kind of feeling for playing together. You have to feel together, and I'm not sure if that's going to be on the screen.

Teachers and students were asked whether they felt performance exams could be conducted via LoLa. A piano teacher remarked that having used LoLa, they felt it would be possible. Students commented that taking a performance examination via LoLa would potentially be more comfortable than in the face-to-face to environment:

> I wouldn't feel uncomfortable at all. On the contrary, there would even be a little more distance, and you would not feel attacked as a person. Of course, I hope that the tone and the energy will reach the jury just as if they were sitting in the same room. Energy could be a problem, because when you see someone on stage, you feel an energy that you don't feel in a film of the concert, for example.

Some of the students remarked that they were increasingly open to using remote learning technologies. A vocal student commented: 'It's just extra. If I should be abroad at some point and then want to communicate with my teacher, then I can well imagine it. Even over a longer period, that's OK'.

A piano teacher remarked that they sometimes found their own institution had better facilities than the institution they had travelled to: 'I can also remember some Erasmus stays where I have better acoustic and quality conditions for the instruments available here […] than there'. Thus, lessons via LoLa could be an advantage as teachers can control the quality of the studio environment and the instruments they use, rather than being in less-than-ideal conditions when visiting another institution.

Participants commented on the economic advantages of not having to travel between institutions. The LoLa developer discussed how the hardware required to run LoLa was now more affordable due to technological advances and lower prices than on the initial release.

### 7.2.2 Pedagogy

Many of the participants felt LoLa could be used to allow teachers and students to join masterclasses from different institutions, and it could allow for extended periods of study with different teachers. Participants considered the

use of LoLa for supplemental lessons. A vocal student commented: ‘I found it very interesting as a supplement. A kind of masterclass with a person who comes from somewhere else and has other experiences and can also give other tips on the pieces that I am currently doing’. They also stated that they would prefer to have met the teacher beforehand in a face-to-face environment: ‘If I know the professor and know exactly what she means, then it is probably easier to work with her on a screen than with someone I don't know personally’.

Most participants felt that LoLa should not be a replacement for face-to-face teaching; however, the guitar teacher felt that LoLa lessons could be used more often, especially when used with other technologies such as recording:

> You could also use LoLa exclusively or 99%. Classroom instruction is a good thing, but it doesn't make sense anymore these days if I don't use technology […] I can interact with LoLa, show things in a different way. The recording as a document and LoLa as a communication tool are complementary to each other. Presence is good for other aspects, but I would question this exclusivity of classroom attendance.

A technician commented on the use of multi-camera techniques to observe particular aspects of technique and posture, such as close-up views of hand positions while simultaneously observing overall posture. They also commented on making recordings for later review by students, without the pressure of a lesson and the ‘compulsion to succeed’. Though not unique to the LoLa setting, multi-camera and recording facilities add to the utility of LoLa as an educational tool.

The possibility of longer-term collaborations with teachers at other institutions was also discussed. A vocal teacher felt that it could be detrimental for less experienced students to work with more than one teacher. This view perhaps represents a more traditional view of conservatoire teaching, and in contrast, a piano teacher felt that LoLa could be used to facilitate ‘team teaching’, allowing students to work with specialists in areas their principal teacher may be less familiar with.

### 7.2.3 Erasmus+ programme

Students at European institutions have the opportunity to study in different European cities for an extended period of time under the Erasmus+ programme. Participants discussed using LoLa to facilitate trial lessons to help students choose teachers, cities and countries to travel to in advance of Erasmus+ exchange or postgraduate study. A guitar teacher reported that not all exchanges go as planned, which can be disruptive for students due to the expense in temporarily moving to a different country. A piano student commented:

> I think it really would help [to decide where to study] because you really see different concepts of teaching and working in different parts of the world. For instance, in China or Russia, it's completely different than maybe Vienna or Berlin, I think. You have to see what suits you, and that would really help if you met the professors and see how they work […] I think I could decide with LoLa, because it's about the connection and if you can work with a person. You get that experience with LoLa. I think it's a very genuine experience.

LoLa could also facilitate a change in the way students participate in the Erasmus+ programme. One interviewer noted in discussion with a participant that students had voiced concerns about losing contact with their main subject teacher while away on an Erasmus+ exchange, and how students may attach great importance to this close bond, perhaps for psychological reasons. The piano teacher had a different perspective on students maintaining contact with their principal teacher while studying abroad, stating that they were 'fundamentally sceptical' of students having an overly strong bond with their principal teacher. In addition, students may want to maintain contact with the Erasmus+ exchange teacher beyond the initial visit, particularly if they have had interesting and enriching lessons abroad.

An important reason for undertaking the Erasmus+ exchange is for students to live in different cities and experience different cultures. A piano teacher remarked: 'For the students, an Erasmus exchange naturally also means getting to know a foreign city'. The accordion teacher commented: 'LoLa does

not allow you to “breathe the cultural atmosphere” of the other's environment, but it can still offer a partial experience, a taste’.

### 7.2.4 The physical and virtual environment

There are many complex and interrelated factors that contribute to the overall feeling of comfort and satisfaction for participants when working in a virtual environment. These include:

- the physical space each participant is located in, with potentially restricted movement around technical and musical equipment;
- the altered sense of presence in the virtual environment, due to altered acoustic and visual environments and the loss of physical touch;
- a potential loss of social interaction with the other participant, but also a possible lack of privacy in the studio lessons due to the presence of technicians;
- instrument-specific issues with camera angles and microphone placement.

A piano teacher discussed the loss of physical presence and restricted movement:

> I change my position in the room. I also leave a lot of space for the students, go to the other corner, also try to take the perspective of the audience, then perhaps also say: ‘now I listen to this part as if I were in the audience and not the piano teacher’. Then I observe the left side of the body, the right side of the body, the back, the front, the facial expression. So, I’m usually pretty busy in a classroom situation. On the other hand, I hardly moved when using LoLa […] It was a difference for me that I didn't feel free to move […] Maybe that was my reluctance, not the limitation of the system. I had simply assumed that I would have to sit at the piano like the student and we would have to put up with it.

Another piano teacher noted missing being able to walk around students and observing them from different angles, a point echoed by a technician who recognised that the participants weren't able to use peripheral vision and were reliant on the monitor in front of them. Several participants discussed the size

of the monitor and its placement. They noted that having a larger monitor would foster a more realistic perception, and create a more effective illusion of closeness, perhaps compensating for the lack of direct physical presence.

The LoLa developer commented that some users were initially affected by the presence of microphones and other technical equipment but was of the view that after a small period of adaptation, most users felt comfortable. A vocal student confirmed feeling uncomfortable surrounded by cameras and microphones, especially as it restricted their ability to move freely, something they felt is crucial for a singer. The accordion student noted missing the physical presence of other musicians, for example, by not sensing the intake of breath before beginning a musical phrase.

Different instruments, including voice, can present different technical challenges in a virtual studio environment. A technician described in detail issues relating to string players and the use of headphones in the studio:

> Strings are dependent on hearing themselves directly with their own ears […] we had the impression that headphones for strings are not a solution, […] acoustically entering a virtual space without having to restrict yourself too much in terms of movement and interpretation is the real problem. This is our most difficult task and is really very difficult to solve.

The guitar teacher from the learning and teaching demonstration (Section 6.4) also reported preferring the experience of hearing the student through speakers as opposed to headphones. There is a danger that microphones can pick up signals from speakers and cause feedback, but this is where a sound engineer or technician can assist.

A vocal student reported that despite initially experiencing difficulty working with a new teacher in the LoLa lesson, they quickly adjusted as they were already familiar with the technical vocabulary:

> I always understood what the professor meant, but that was only possible because I had some experience in vocal technique. As a

> beginner, or someone who doesn't know the vocabulary: ‘sing more in the mask’, ‘in the seat’ or suchlike, I wouldn't have understood that […] if you don't know exactly what is meant in terms of playing or vocal [technique], you can't improve it yourself because the other person is just behind the screen and can't really show it […] if that were my first singing lessons at the university, I would have missed something. You just need this very precise demonstration, imitation, and you also have to see the person, and you have to listen very carefully.

The accordion teacher remarked on the usefulness of physical contact with the student, for example by pressing on the student's accordion bellows to highlight the physical sensation coming from a certain type of gesture. The vocal student also described the importance of touch in singing lessons:

> It is very useful if the teacher simply puts his hand on his back and shows where to breathe, and not only says verbally: ‘Breathe in the back!’. But that also depends on the individual student. It helps some if the teacher says: ‘Push the air flow against it right here!’. You can also show that on the screen, yes, but if the student is not that advanced, the effect will not be the same.

The saxophone student commented on initial problems with hearing changes when their teacher demonstrated producing different tone qualities:

> Among other things, the professor talked about my sound quality on the saxophone, especially in the upper register. He showed me different variations and showed me how it could sound better. And I didn't always hear the differences. Maybe it was also the room acoustics.

However, the teacher was able to explain how to make changes to the student’s embouchure to improve the tone quality: ‘I felt that it sounded better in my room than before, and I also felt that he had received it that way’.

### 7.2.5 Attitudes and perceptions to using LoLa technology

Adopting new technologies and pedagogies can be problematic in institutions. A technician reported that senior management in their institution had

previously been reluctant to introduce online learning: ‘Earlier rectorates generally rejected e-learning. There was even a rectorate decision that the [institution] will not conduct e-learning’.

The technician reported that some teachers were initially sceptical about using LoLa, but that their attitude had changed having used the technology: ‘I was pleasantly surprised that some teachers, who were initially very sceptical about the matter, suddenly said: “This is much easier to handle than I thought it would be”’. The technician also commented that some teachers did not wish to participate: ‘it doesn't win over people who basically think that it doesn't work’.

The piano teacher described how their attitude had changed after having used LoLa:

> I was a bit sceptical at the beginning. I thought that a teaching situation where the students are not in the same room as the teacher might not work. I was therefore very amazed that in a very short time I almost forgot that the students are not physically present in the same room and that a very nice and, from my point of view, very useful lesson was possible. And I do believe that it worked so well because of the high quality of the transmission.

The vocal teacher commented that accepting LoLa is a matter of personal mindset, and that having experience of using LoLa can help to overcome negative preconceptions. They also commented that students may not accept this type of technological innovation easily or quickly. In questionnaires sent to participants prior to the trial, it was noted that students tended to be more sceptical than teachers. However, the piano teacher reported that their students had showed great interest in the project, with many cancelling other appointments in order to participate.

Participants reported being satisfied with the overall experience, particularly the sound quality. Comments included: ‘The teacher's tone was extremely good, and it was very easy to communicate. There was no delay either. The picture wasn't super sharp, but it wasn't that important’, and ‘I was very

surprised by this sound. I didn't know it would be as good at as it was. And I heard everything'.

### 7.2.6 Future developments

Participants discussed possible technical improvements in the LoLa system. These included improvements in monitoring and microphone placement so that participants could enjoy improved audio quality with less physical restriction. Improvements in the quality of the video were also discussed, including the use of larger screens and projections onto the wall of a studio.

The guitar teacher stated a preference for a more compact and mobile LoLa system that could be operated without the need for technicians present. The LoLa programmer noted that the Polycom system is simpler to use than LoLa, as users simply turn on the apparatus and are able to immediately start a lesson. However, the programmer felt that technicians are necessary in a LoLa session to ensure high-quality audio and video capture and reproduction.

As to whether LoLa could ever completely replace the traditional lesson, most participants did not feel it should. A technician commented:

> Most of the teachers were very sceptical about these things. These teachers started every conversation with the sentence: 'It will never be able to replace the teaching'. I am also of the opinion that it will never replace teaching. But that was never the goal, at least not direct teaching in the same classroom. After all the attempts and after all these sessions that we have made, it emerges that LoLa cannot replace teaching, but it can also offer opportunities that direct teaching does not have, and that's what interests me.

The technician's comments align with my own experience. For example, I still believe that face-to-face teaching offers an experience as yet unmatched by any technology, but LoLa has managed to solve the two biggest problems of standard videoconferencing platforms: poor audio quality and not being able to play together. In solving these problems, LoLa offers many new

opportunities for students and teachers to interact that expand the possibilities for learning and teaching beyond the four walls of schools, universities and conservatoires.

## 7.3 Discussion

### 7.3.1 Introduction

The SWING project is the first qualitative case study to specifically explore attitudes and mindsets concerning the use of LoLa for teaching in conservatoires. Participants in the study were drawn from three European conservatoires including teachers, students and technicians, and also different instrumental types, including voice, piano and guitar. There is some commonality and overlap with the data from HE participants in Chapter 6, but by including a wider range of participants from different backgrounds, the study allows for greater depth and breadth of data to be presented on pedagogical aspects of LoLa.

### 7.3.2 Pedagogical considerations

Most of the participants agreed that LoLa should not replace traditional face-to-face lessons in the conservatoire, but that it could be a useful supplement, and they suggested a range of ways in which LoLa could be used in conservatoires that aligns with more recent literature on pedagogy in HMEI settings.

Gaunt and Westerlund (2013) argue for challenging established forms of music education and extending pre-existing realities. Literature from the past decade cautions against students becoming overly dependent on their teacher in a master-apprentice dyad (Gaunt, 2008; Renshaw, 2010; Zhukov, 2012; Zhukov and Sætre, 2021); Burwell et al. (2019) argue that students should experience input from different teachers. The findings show that LoLa offers students greatly expanded possibilities for learning, rehearsing, and performing with teachers and students from different institutions, thus

disrupting the traditional master-apprentice model and potentially enhancing the student experience.

Other recent literature recommends co-teaching (Clauhs and Newell, 2013; Zanner and Stabb, 2013) and as reported in the findings, LoLa can easily facilitate teaching exchanges between different conservatoires. LoLa affords students opportunities for interventions from different teachers at an appropriate stage of their studies, whether on an ad hoc basis, or as part of an ongoing 'continuous masterclass'. Other suggestions from participants included teachers exchanging students for one lesson every few weeks with no associated travel costs.

Many participants were in favour of these increased opportunities, while other teachers and students expressed more traditional conservatoire values, such as a vocal teacher and a vocal student who were of the view that learning with more than one teacher via LoLa could be detrimental to a student's progress. However, this may be more of a concern for vocal students whose voices can be damaged through vocal misuse (Trollinger and Sataloff, 2018) than for other instrumentalists. Zeltsman (2003) describes how students who choose to take lessons with different teachers may become confused and disheartened by conflicting advice. In my own learning, I have often received conflicting advice from different teachers. For example, some percussion teachers have opposing views concerning the 'best' way to hold the mallets (Chapter 5, Section 5.2.1), and the optimum keyboard height for marimbas and vibraphones. In the traditional master-apprentice setting, the teacher is the authority that students defer to, but ultimately, it is for students to decide whether to follow a particular teacher's advice or not. My view is that the more opportunities students have to try different approaches, the greater their knowledge and understanding, and the more likely they are to find an approach that suits them.

Gaunt and Westerlund (2013) argue for collaborative learning, including meeting new social situations and navigating cultural differences, and students from the trials were enthusiastic about learning with teachers from

different musical cultures and backgrounds. LoLa allows students to form communities of practice (Wenger et al. 2002) between different institutions, and to learn from each other. Teachers can benefit from observing their own students learn from different teachers (Chapter 4, Section 4.3.2), and thus explore new ways of teaching to inform their own teaching practice and professional development (Duffy, 2016). Furthermore, a greater exchange of teaching and collaboration between institutions would allow common benchmarked standards to be met across institutions. This would be beneficial for students wishing to study at a different institution as part of an Erasmus+ exchange or for a longer duration, to ensure they met the standards of the new institution.

Zhukov and Sætre (2021) describe a 'teaching-through-playing' approach to developing a student's musical and social skills through collaborative chamber music instruction. They also noted the importance of matching the skill levels of participants in group learning. Soloists and ensemble players now have the possibility of using LoLa to rehearse and perform with a much larger pool of teachers, accompanists, and ensembles, meaning they are no longer dependent on the availability of teachers and musicians within their own institutions. Even without the current disruptions to travel from COVID-19, my view is that it makes sense to harness the opportunities afforded by LoLa for remote international musical co-operation and collaboration, including rehearsing and performing.

Students reported wanting to experiment with using LoLa for rehearsals, but also felt that they would prefer to rehearse face-to-face prior to a performance. This assumes that the performance would be co-present, and in my experience of performing, it is highly likely that the musicians would rehearse in the venue prior to a performance. However, since LoLa can also be used for remote performances, there is no need for musicians to ever meet in person. My view is that remote rehearsing and performing is likely to become more commonly used as low-latency technology improves and becomes more widely available.

Some students reported welcoming the possibility of being examined via LoLa by teachers from a different institution, feeling it freed them from the pressure of performing in front of teachers from their own institution. It is usual practice in UK HMEIs such as the Royal Conservatoire of Scotland and Edinburgh Napier University to have external examiners visit institutions for performance exams, and whereas this facility already exists via standard videoconferencing, the high-quality audio of LoLa may give some reassurance that examiners would have a good aural representation of a student's performance.

### 7.3.3 Research question 1: What changes in the quality of the interactions and the learning and teaching experience in lessons between face-to-face, standard videoconferencing, and low-latency environments?

Participants reported being satisfied with the overall experience, particularly the audio quality. Comments from a student included: 'The teacher's tone was extremely good, and it was very easy to communicate', and from a teacher, 'I almost forgot that the students are not physically present in the same room […] and I do believe that it worked so well because of the high quality of the transmission'. In my earlier trials (Chapter 6, Sections 6.2 and 6.3), I had been attempting to discover what the minimum bandwidth requirement was for an acceptable lesson via LoLa. However, the findings from the SWING project suggest that the quality of audio, video, and the connection are of high importance to the overall satisfaction of the experience when using LoLa, and that if the technology is to be more widely adopted, more bandwidth should be prioritised by institutions so as to achieve the highest quality experience possible.

Participants commented on the loss of physical presence, including being able to touch and adjust posture and instruments, and also missing the presence from peripheral vision and sensing another musician's breathing to assist with musical cues. Participants also commented on the restricted movement in the studio due to microphones and cameras. However, this

could be partly overcome by more planning of the studio space, for example, using hanging microphones. Participants also reported becoming more accustomed to working in the studio space after a period of time.

The findings show that different instrument categories have different needs in the virtual studio environment. String players were reported being uncomfortable having both ears covered when using headphones, though there are already headphones available that would allow them to hear themselves for intonation purposes. Monitors could also be used instead of headphones with careful setup to avoid feedback, as in the learning and teaching demonstration of LoLa between RCS and Edinburgh Napier University (Study 11, Section 6.4.3).

### 7.3.4 Research question 2: Are some elements of music instruction more or less effective in these different environments?

Participants commented on the Erasmus+ exchange not only being about learning at a different institution, but also being totally immersed in a different culture. This aligns with the comments from the tabla student (Chapter 4, Section 4.3.8) and this would be missing if a student was to study exclusively via distance learning. However, lessons via LoLa would allow students to gain fundamental instrumental techniques and musical concepts in an unfamiliar style of music or instrument before moving to a new institution or country for more intensive study.

The development of LoLa is partly dependent on teachers and students giving feedback to help developers further improve the system. Some of the technical suggestions made by participants from the SWING project have since been implemented by the LoLa development team, including the introduction of multi-camera setups that allow the use of up to four cameras in each location, allowing teachers and students to view each other from different angles, and also close-up and distance views. Simultaneous performance is now also possible from three remote locations, and was publicly demonstrated for the first time at the AEC annual congress on 6

November 2020 by a jazz trio distributed between Italy, Austria, and Estonia (Norman and Volpe, 2021).

There were requests from participants for further improvements to the audio quality, including achieving sound that gives the impression of being in a three-dimensional space. Whilst these technical developments would potentially improve the experience of using LoLa, there were also requests to make the system easier to use, so that musicians could be independent from technicians. Thus, there is a trade-off between improved technical quality, while also keeping the equipment easy to set up and use.

### 7.3.5 Research question 3: What are the barriers to using these technologies in educational settings, and how can these be overcome?

Adopting new technologies in institutions can be problematic and may be met with scepticism (Brudvik, 2018). Some teachers would not engage with the LoLa trials, and a technician from this study reported that the directorate of a European conservatoire had previously decided that it would not engage with e-learning. This decision has, perhaps unsurprisingly, changed since 2020.

Many participants in the study also reported overcoming their initial scepticism of the technology and being pleasantly surprised once they had used LoLa, particularly with regards to the audio quality. Thus, attitudes are important, and management, teachers, students and support staff need to have confidence that the technology will bring benefits and is accessible and useable.

Kotter (1996) developed an eight-step model for creating transformation and lasting change and within organisations. The model recognises the need to create and convey an inspiring vision, and if the change is to be successful, for members from all levels of an organisation to be involved in implementing the change. The need to manage rapid change in education was particularly evident in the early stages of the COVID-19 pandemic, and the Kotter model

was updated in 2020 to assist education organisations in planning for these changes (Buzan and Whitehead, 2021).

In my experience of trying to introduce LoLa to the Royal Conservatoire of Scotland, problems of perception first needed to be overcome before the technology could even be considered for further trials. Having successfully demonstrated LoLa technology at the RCS Learning and Teaching Conference in September 2019, some interest amongst staff was generated, but no substantial progress was made in using the technology between RCS and different institutions. This was partly due to the building being closed in March 2020 because of the pandemic, but mainly because no strategic institutional plan for taking the technology forward had been developed or shared with staff (as per Kotter's model), so this outcome was perhaps unsurprising.

Based on my experience at RCS, my view is that in order for low-latency technology to be more firmly embedded in HMEIs, schools and hubs, a plan similar to Kotter's eight-step model should be enacted. Stakeholders should be included in the process, enthusiasm generated, and a vision of transformation should be shared.

### 7.3.6 Final reflections

The findings show that LoLa facilitated instrumental music lessons between conservatoires in different countries, and that participants were impressed by the audio and visual quality of the platform and the ability to play together in real time. As suggested by many of the participants, the technology opens up many new possibilities for collaborative learning, co-teaching, and opportunities for students to learn, rehearse and perform with teachers and students from different countries and cultures.

However, despite these new insights gained from the SWING project, it is difficult to make generalisations from this study. The students and teachers in the trial had a relatively limited experience of using LoLa, and the research

took place in 2019, since when the working environment of conservatoires has radically changed due to the pandemic.

In light of the restrictions on travel and the need for social distancing, as well as the imperative to reduce carbon emissions from travel, the discussion on whether online technologies can, or should, support instrumental teaching in conservatoires has moved on. The findings show that low-latency technologies have an important part to play in the teaching strategies at HMEIs, and this could also be extended to schools and hubs for outreach work. In addition to providing an effective way of teaching between remote locations, LoLa can also facilitate remote working within institutions. This is particularly relevant for vocalists, brass and woodwind players, where there may be restrictions on rehearsing and performing with others due to the need to control the risk of transmitting COVID-19 through the production of minute water droplets.

Based on the findings, future research by the SWING project or independent researchers could include longitudinal studies with students and teachers from a broader range of instrument categories, including brass and percussion, and different genres, including jazz and folk/traditional music. Trials could attempt to find the optimum technical set up for specific instrument and teaching situations. The use of fixed and mobile LoLa stations could also be investigated, along with ways of improving the sense of 'presence' in the online environment by attempting to match acoustic and lighting settings in remote locations. A major technological improvement of LoLa would be the ability to operate over a standard network without the need for specialist technical support to navigate network firewalls.

This chapter has built on the findings from the initial LoLa studies in the previous chapter and demonstrated that LoLa has the potential to facilitate collaborative learning across HMEIs, schools and hubs. However, as reported in Chapter 6, Section 6.7.4, the cost of LoLa and the need for a high-bandwidth network, technical support and associated infrastructure may be prohibitively expensive for smaller institutions. The next chapter reports on

JackTrip, a low-latency audio-only technology that operates on inexpensive equipment over a standard network without the need for expensive infrastructure.

# Chapter 8: Low-latency audio-only: JackTrip

## 8.1 Introduction

This chapter reports on JackTrip low-latency audio-only technology. The chapter is organised in seven sections: introduction, in which the JackTrip technology is described; a section on the origin of JackTrip in Networked Music Performance; the development of JackTrip and its use on different types of network; a report on a small-scale 'test of concept' trial using JackTrip that took place at Edinburgh Napier University in February 2020; an interview from December 2020 with a vocal teacher that participated in teaching trials of JackTrip at a University in the United States in late 2020; an interview from February 2021 with Sarah Weaver, who has expert knowledge of JackTrip and extensive experience in the medium of Networked Music Performance as a composer, conductor, and technologist; and a discussion section which responds to my research questions.

JackTrip is a low-latency, high-quality audio-only free and open source software program developed for use over the Internet (Cáceres and Chafe, 2010). JackTrip was previously known as the 'high-quality option but difficult to operate' (Section 8.6.2) and as with LoLa, it required an institutional network to operate. Since the COVID-19 lockdowns of March 2020, the developers have refined JackTrip to the point that it can now operate on standard networks between domestic properties, and for users without specialist technical knowledge, a standalone 'plug-and-play' Virtual Studio device can be purchased with JackTrip pre-installed.

Later in 2020, JackTrip was trialled on standard networks for instrumental music teaching at a University in the United States, and also for multi-user rehearsal and performance with a boys choir, the Ragazzi Boy's Chorus in Northern California (Kotapish, 2020). Ferguson et al. (2020, p.5) report on JackTrip 'currently finding use home-to-home […] and benefiting from commodity cloud services networks'. Being able to operate on a standard

network represents a significant development in low-latency technology and makes it much more accessible, which therefore increase the possibilities for use.

In addition to JackTrip, other low-latency audio-only systems are available including JamKazam, Jamulus and RealTime Audio. I have previously experimented with trying to connect with other musicians using JamKazam from home. The software was easy to download, and the user interface relatively easy to navigate, but even after several attempts, I was not able to connect. I decided not to pursue this due to the unreliability of the technology. A blogpost from Midnight Music (Wardrobe, 2020) also noted numerous problems that users experienced when trying to connect with each other via JamKazam.

## 8.2 The development of JackTrip

In response to the COVID-19 pandemic, the JackTrip Foundation was formed as a collaboration between Stanford University's Centre for Computer Research in Music and Acoustics (CCRMA) and Silicon Valley software entrepreneurs. The mission of the Jack trip foundation is ‘to make the performance of music over the Internet feasible and accessible to everyone’ (JackTrip Foundation, 2021a).

Mike Dickey, a board member of the JackTrip Foundation, developed the JackTrip Virtual Studio so that users without specialist technical knowledge could operate the software using a standalone device with the software pre-installed. The most significant recent development of JackTrip is the ability to operate over standard networks, utilising two commonly used methods of connecting multiple devices via the Internet. Unlike LoLa, JackTrip does not require network firewalls to be bypassed.

In the point-to-point (P2P) or peer-to-peer method (Figure 2 below), each performer’s computer sends audio directly to the other performer’s computer, which then mixes each individual audio stream together. The advantage of

this method is extremely low latency without the need for a central server. The disadvantages are the need for each individual user to have high bandwidth, high processing power on their computer, and changes to firewall ports which requires some technical knowledge. While achieving the lowest latency in smaller groups below 12 performers, this model is not suitable for larger groups (JackTrip Foundation, 2021b). P2P is therefore the most suitable method of connection for the LoLa platform, due to the extremely low-latency of the connection, the presence of a high-bandwidth connection, and the high processing requirements of the computer.

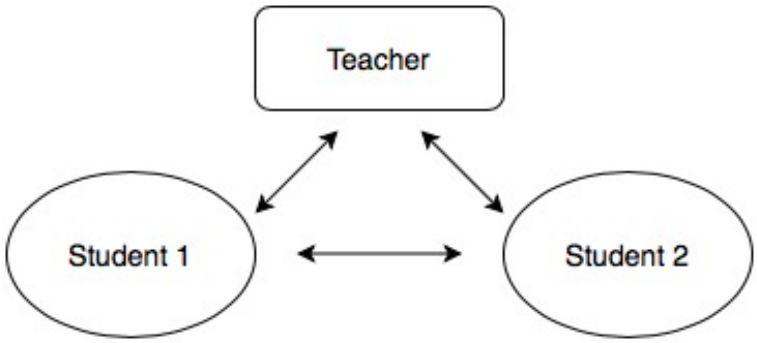


*Figure 2: Point-to-point network connection*

In the client-server model (Figure 3 below), each performer's computer sends their audio signal to a central 'cloud' server, which then mixes all the audio streams together and sends a single copy back to each individual performer.

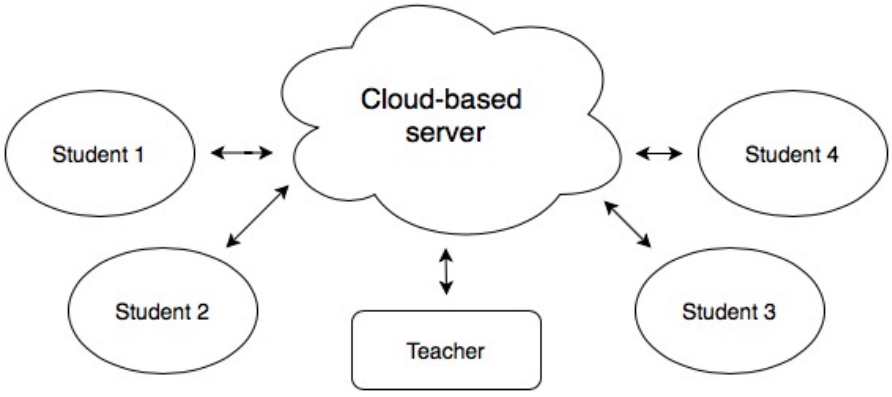


*Figure 3: Client-server network connection*

The advantage with the client-server network connection is that it does not require changes to a home internet firewall, and since the server is mixing the audio streams, there is minimal processing and bandwidth requirements on a device, regardless of the number of performers. The disadvantages with the client-server connection are that it requires the configuration of a hub server, and some latency is added through an additional stage in the audio path (ibid.).

In an interview published in September 2020 (Kotapish, 2020), Mike Dickey, one of the developers of JackTrip Virtual Studio, described how JackTrip can use both methods for connecting to the network, and how it compares to other low-latency audio-only software programs such as Jamulus:

> Most platforms use a 'peer-to-peer' (P2P) technology model, which limit their potential scale to only a handful of musicians. Jamulus uses a 'client-server' model, which enables it to support many more musicians than P2P. However, Jamulus has a single-threaded design that still limits it to about 30–50 musicians. After that it hits a wall, regardless of how much computer power you are able to throw at it.
>
> JackTrip is unique in that it supports both 'peer-to-peer' and 'client-server' models, and it scales extremely well for large groups. I've simulated up to 500 concurrent musicians running JackTrip using a single audio server. Real world usage doesn't always map to lab testing, but we've been running live rehearsals for the past few months with members of Ragazzi, Cantabile, and Stanford's Marching Band. Soon we plan to start running live rehearsals involving hundreds of choral members.
>
> Jamulus and other platforms also use lossy audio codecs, while JackTrip uses lossless, studio-quality sound. The difference in quality is quite noticeable, and this is especially important for professional organizations who want to record and perform for live audiences (Kotapish, 2020).

In addition to allowing the technology to run via standard networks and the development of the JackTrip Virtual Studio, the JackTrip Foundation also began offering certification programmes in 2021 to assist new users in

running the open source version of JackTrip, as well as the aforementioned Virtual Studio.

## 8.3 Study 15: JackTrip trial

### 8.3.1 Introduction

JackTrip users have the option to use JackTrip on its own without the video element, or to combine the low-latency audio of JackTrip with the video element of a standard videoconferencing platform, albeit not synchronised.

From the earlier research with both videoconferencing (Chapter 4, Section 4.3.6) and LoLa (Chapter 6, Section 6.5.2), the video element was considered to be an important element by participants. Furthermore, the LoLa trial participants reported that when the audio and video were not synchronised, they used the video element less. In addition to my main research questions guiding the whole thesis, the specific research question relating to this trial was whether JackTrip could be used in combination with a videoconferencing system to give an acceptable user experience.

The trial took place at Edinburgh Napier University in February 2020 with Dr Ferguson in charge of the technical and studio arrangements, myself in the teaching role, and two music students in the role of learners. Student X was a BMus student specialising in drum kit; Student Y was a PhD candidate with a background in music technology and audio engineering, and with a role coordinating music instruction in high schools. The participants were recruited through my personal connection with Student Y who then assisted in recruiting Student X through the university music department.

As with the earlier trial with LoLa at Edinburgh Napier University (Chapter 6, Section 6.2) snare drum duets and the Steve Reich piece *Clapping Music* were used in the trial lessons to allow participants to focus on achieving precise timing while playing remotely using JackTrip. I initially worked together in the same studio with Student X to warm up musically and to achieve a performance baseline from which we could judge the remote lessons. We

then moved to separate studios and continued the trial using LoLa while Student Y assisted Dr Ferguson with the technical arrangements. The LoLa settings were picture quality 1024x768 RGB24 at 30 FPS in both directions; compression quality of 60% was added to give an estimated bandwidth of 17 Mbps, so it was operating at the lower end of the limits we had previously considered acceptable for teaching.

The next stage was to continue the trial using JackTrip installed on the music department PCs for the audio element together with LoLa for the visual element. We had limited studio time and so rather than spending additional time setting up Zoom or Skype, the decision was taken to use LoLa for the visual element as it was already set up. Buffers were added to the LoLa system to simulate the latency of approximately 200 ms in a videoconferencing system such as Zoom or Skype. Following the trials, I interviewed both participants to discuss their experience. The interviews were recorded and then transcribed.

### 8.3.2 Findings

In the trials with Student X, musical pieces had to be restarted several times even in the face-to-face setting. A possible explanation is that Student X was unfamiliar with the pieces and nervous working with a new ‘teacher’. There was a slight improvement when using LoLa, which could be accounted for by Student X feeling slightly more relaxed, and also being more familiar with the music by this stage. Another explanation is that by working remotely, there was less ‘pressure to succeed’.

Student X commented on the LoLa trial compared to the face-to-face experience:

> I thought it was fine, I didn’t really feel it was too much of a difference. I feel like we were out of time slightly at some points, but I think we were like that when we were face-to-face, and probably just as much to be honest.

I asked Student X how useful the visual cues were when using LoLa: ‘it was fine for between actual playing, so it was good to have the visual, but when I was playing, I was just looking at the sheet music’.

Following the trials, we discussed the experience of using JackTrip compared to LoLa:

> I feel that maybe there was a tiny bit of lag. I was wondering whether it was maybe my playing but thinking about the first trial we did with LoLa, I think there was just slightly more lag [with JackTrip]. We played the same two pieces, but I didn’t feel as comfortable.

We also discussed playing the piece *Clapping Music* using JackTrip, and how important the now out-of-sync visual element was for coordinating the shift between each repeating bar:

> I think that was important to see you on the screen for that piece especially, because I could look up at the screen because I knew my part. For the other piece, I was looking at the music because I didn’t know it off by heart, but we were still able to play.

The trials continued with Student Y in the learner role. We discussed the latency and audio quality of using JackTrip:

> From an audio perspective it sounded fine to me, I didn’t notice any latency, it sounded good, but the thing I noticed that was slightly off-putting for me […] with headphones on I didn't find it as immersive as when you're actually there in the room with another person, and you're getting the natural acoustics and reverberation of the room.

The synchronisation between the audio and visual elements was considered important:

> The other thing that was off-putting I suppose was the lack of synchronisation between what I was hearing in the headphones, and what I was seeing on the screen. I was watching you count me in, and hearing you count me in, but the two weren’t in time […] the audio arrived quite a bit before I actually saw it.

The visual element was considered important, even if only for the social interaction between playing together:

> I think it's good to have it there, and as you say, for the social interaction. It was really important to be able to see you, even if we're not totally in sync., and I don't think it matters so much when we're just talking. And again, having you in the peripheral vision as well can be useful too, just as a reminder that you're still there.

I asked Student Y which learning environment they felt was best for virtual instrumental lessons:

> I think LoLa is. It's just the usability, being able to set it up, that would be the one thing that makes it a bit hard to use. But for everything else, it's probably the best because you have the video and the audio being perfectly in sync with very low latency. But with JackTrip, from an audio perspective, I couldn't notice any difference between that and LoLa from using that before, because the latency is just so small that it's not even really obvious that it's there.

Student Y felt that a hybrid JackTrip system would be useable in schools, and it would be possible for students to overcome the lack of synchronisation by not looking directly at the monitor, and the teacher could switch back to Zoom for synchronised audio and video for the social interaction during a lesson. However, the practical issue of students being able to set up the technology was a concern, as was the reliability of the internet connection.

### 8.3.3 JackTrip trial summary

The trial was a test of concept to determine whether JackTrip could be used in combination with a videoconferencing system to give an acceptable user experience for instrumental lessons. The findings showed that we were able to perform synchronously in much the same way as LoLa. Both participants felt that the JackTrip hybrid system gave an acceptable experience for learning.

In comparing JackTrip and LoLa, Student X felt JackTrip had slightly more latency, whereas Student Y and I did not notice a difference. Student X commented that the audio quality was slightly less nuanced using JackTrip, though Student Y felt that the audio quality was good. Student Y noted that the sound quality lacked the natural acoustics and reverberations found with performing in a face-to-face setting. However, that would also be the case with any remote system, including LoLa.

Both participants noted that the visual element was important. Student Y commented that the lack of synchronisation between the audio and visual elements was off-putting when using the hybrid JackTrip system but commented that this could be partly overcome by not looking directly at the monitor when performing.

The main concern of Student Y was the practical aspect of setting up LoLa or JackTrip in educational settings. They commented on the need for making low-latency systems easy to operate, and felt that technical assistance would be required, especially regarding connecting to networks and navigating firewalls. It is worth noting that using JackTrip on a PC required typing command lines on the user interface and Dr Ferguson was in charge of this aspect. Some years previously I had attempted to use JackTrip, but I was unsuccessful, partly due to the complicated nature of the interface, and also due to problems with configuring the internet connection.

My experience as a teacher with experience of using videoconferencing and LoLa was that JackTrip had excellent quality audio; as good as LoLa, and better than videoconferencing. I was not aware of any difference in latency between JackTrip and LoLa. However, this test was in a closed studio environment, and a side-by-side comparison under different conditions may have given a different result. The lack of synchronicity between the audio and visual elements was slightly off-putting, but as suggested by Student Y, this could be mitigated by not looking directly at the screen. I planned my visual cues in advance so that the students could see movement in enough time when a cue was needed, such as changing bars in *Clapping Music*. I was

satisfied from the trial that JackTrip was more than acceptable for learning and teaching purposes.

The trial was small-scale and limited in scope and in itself, the findings are not particularly significant. However, the real importance of the trial was that it convinced me that the JackTrip system had the potential to be an inexpensive and reliable low-latency alternative to LoLa. In light of COVID-19, JackTrip now seemed to offer a serious option for teachers and students to connect remotely and to be able to play together synchronously. The next section discusses a university teacher's experience with using JackTrip during lockdown via the Raspberry Pi device over ordinary networks.

## 8.4 Study 16: Interview with a university vocal teacher

### 8.4.1 Introduction

In November 2020, I contacted Chris Chafe, developer of JackTrip, who circulated a request on my behalf to interview teachers with recent experience of using JackTrip. The first interview was conducted in December 2020 with a teacher at a US university music department (Teacher Z). The teacher coaches vocal students, accompanies students on piano, and conducts ensembles. The aim of the interview was to understand the teacher's experience of using JackTrip on a standalone device, and their impression of the audio quality and the overall usability of the system.

### 8.4.2 Interview data

The university provided teachers and students with the standalone Raspberry Pi device with JackTrip pre-installed, along with the microphone and mic stand in September 2020 at the start of the new academic year. Over the summer of 2020, trials had taken place with some staff using an earlier version which required typing some command lines into the device. The newer version was more 'plug-and-play', but there were still teething problems with getting the device to connect to the network via the teacher's mobile phone. This was apparently due to difficulties with the university Wi-Fi having

two-step authentication, whereas most students living off-campus did not experience the same difficulties. The teacher felt that there could be further improvements in terms of usability and clearer instructions.

Teacher Z felt the audio quality was good, though ‘it's not like real life’. They went on to describe difficulties with balancing the sound with multiple users:

> We were singing a trio from a Mozart opera, and it's kind of hard to get the balance between the different people, because they're in different places and they've got different equipment, so that's a little weird, but it's something!

We discussed the overall user experience of JackTrip. The main difference noted between JackTrip and standard videoconferencing platforms was that the teacher was able to play together with students on JackTrip. However, latency was still an issue:

> The first time we got JackTrip to work, oh my goodness, my students and I, we didn't want to stop. It was just amazing. It was just so liberating. And then a week passed, I saw them for the next class, and by then it was not a novelty anymore, we were ready to get proper work done […] By the time I got to the end of the second session, I was exhausted. And that was because they were singing together, I was accompanying them on the piano, and I felt like I was pulling them through mud.
>
> So, my point is that low latency is not zero latency, and they will always be fractionally behind. And that happens in real life when singers don't know their music that well […] and so, I found by the time I was at the end of my hour-and-a-half of playing, I walked out of there and my shoulders […] oh my goodness, it felt like I was carrying these two sopranos on my shoulders.

Teacher Z stressed the importance of students being prepared and knowing their music in advance:

> If I had professionals rather than university undergrads working with me, I think it would have been pretty damn good. As a teaching tool, if I had somebody who was anticipating and knew the music and was leading me […] I think it would be a different story.

We discussed using the parallel system of Zoom alongside JackTrip for visual cues:

> When I'm accompanying in real life, I'm good at following people, but I'm also very good at anticipating what they're going to do wrong, I can feed them notes, and I conduct from the piano and all that sort of thing, I can't do that [with JackTrip].

> There's a delay, so I can't really give a pickup, or if I did give a pickup, they would be late. So, what I did instead was I gave a lot of audible cues, but that means I end up hyperventilating […] And I think with the visual thing, I tend not to need it because normally I'm at the piano, and I hear them breathe, and I breathe with them. I don't have to see them that much.

However, Teacher Z went on to mention the usefulness of having peripheral vision, and feeling that for some musicians, having difficulty in seeing cues may be problematic. The approach I took to this during the JackTrip trial (Section 8.4) was to give clear cues slightly ahead of where I would normally give a cue in a face-to-face setting, so this would not be an insurmountable problem.

Teacher Z did not feel that JackTrip could replace the experience of face-to-face lessons, but that it would be useful to carry some elements of teaching with JackTrip over once social-distancing restrictions have eased, including rehearsals to work on specific details of a piece if it was more convenient than meeting face-to-face.

## 8.5 Study 17: Interview with Sarah Weaver, Network Arts practitioner

### 8.5.1 Introduction

The second interview took place in February 2021 with Dr Sarah Weaver, board member of the JackTrip Foundation, and director of NowNet Arts, a leading organisation for Network Arts. Weaver has extensive experience in the field of Network Arts as a composer, conductor, technologist, educator,

and researcher. The aim of the interview was to understand more about the development of JackTrip, the technical problems affecting usability, and how JackTrip was being used in education from Weaver's expert perspective.

### 8.5.2 Interview data

According to Weaver, the origins of JackTrip are in Networked Music Performance (Section 8.2), a medium which has a number of inherent latency factors which make the performance of 'steady-beat music' problematic. We discussed approaches to composing music for the Network Arts medium that weren't reliant on having a 'steady beat':

> There are tools we could use such as heterophony, polyphony, multiplicity, that express other types of time dimensions that are also in our world […] Or, you're going in the direction of texture, or drone, call and response. There are a number of musical approaches that can be utilised in this medium that are not unique to it.

Prior to the pandemic, JackTrip was reported to be mostly used in education for teaching in the Network Arts medium, rather than for instrumental music teaching, but more recently it has been adapted for educational purposes beyond Network Arts: 'that shift has occurred because the need arose, and obviously on a much greater scale'.

As described in Section 8.3, software developers have worked to make JackTrip more accessible and useable. One of the developers, Mike Dickey, has a son in the Ragazzi Boys Chorus in Northern California:

> He wanted to be able to have his son's choir be able to rehearse and perform from home […] so he developed the Virtual Studio version of JackTrip. That's a hardware version that does not require a heavy technology background, it's a bit more plug-and-play, and doesn't require particular computers to use. There are still some technical requirements, but it made it much more accessible to be able to be used from home by people without prior technical knowledge. So that was a big development.

From there, the software developers in CCRMA worked on developing JackTrip to be able to work over domestic networks:

> So prior, it did not work from home. There had been previous attempts and they didn't quite make it, but with so much concentration and with the demand for that, the hub mode was really emphasised, utilising remote servers. And so that first of all allowed people to use JackTrip without having to open up firewall ports, which was a big hindrance before when running it from home. And then also hub mode using a remote server took the heavy load of the bandwidth onto the remote server, instead of requiring that from the site […] And also, the quality of service on those private networks we have been using previously, there's been a lot of accommodation for being able to run home internet, just in terms of refining buffer sizes and other types of accommodations to clean up the home signals.
>
> So, this has really been the first era where we've been able to run it from home, and it has been working on a wide scale. There are large ensembles that can run internationally, let alone locally. So locally, you could do it, especially for trying to maintain that steady beat, if you have a remote server that's local and all your performers and participants are local.

We went on to discuss factors affecting latency. The first was the speed of light, which determines the signal speed on fibre optic cables which run at approximately 70% efficiency. Thus, the greater the distance between participants, the greater the latency. The JackTrip programme itself has a latency of approximately 5 ms per 1,000 km: ‘as a software, it’s really as fast as you're going to find’. After that, the hardware used to operate the software was a determining factor:

> If you're running open source JackTrip then it's good to have knowledge of what types of hardware cause more latency. For example, USB interfaces cause some latency, or if you are running a DAW [Digital Audio Workstation], getting the sound from the DAW into JackTrip, there's going to be some latency.

The next factor was the location of the internet server. P2P connections were previously used over academic networks as they were more direct and thus

faster with a ‘cleaner’ signal, but more recently, there has been a growth in the use of remote cloud servers, though they need to be based as close to users as possible: ‘I think the development of these remote cloud servers is also in development with the Internet […] there's a sudden attention on that far beyond our field’.

We went on to discuss using JackTrip for instrumental music lessons:

> I think that element is emerging in JackTrip, because I think JackTrip is known as the high-quality option, but difficult to operate. And so, advising people to utilise this with private students that don't have a technology background, that I think is still on a roll out. So, people are now using Virtual Studio for those purposes.
>
> But I think right now, it's the main software we use for large ensembles. We can get 60 to 80 people going all together, and that's a special capacity. I would say there’s been more attention on it in terms of education on large ensemble work because it has that capacity. And the private lesson work, I think that is still emerging as the technology has become more accessible, but maybe was not as accessible in the past.

Weaver described the audio quality:

> JackTrip is known for its audio quality because it’s uncompressed, low-latency, multi-channel audio, so that’s the best audio quality you're going to get in any type of audio system. Basically, you can get the raw signal in that way, and then you can shape it from there as you'd like. There are more parameters being built in, or attributes that you can invoke, such as a limiter, different elements you could add, but JackTrip itself is really the raw audio. So then from there, the quality would be determined by the Internet that you have, and then the microphones and the speakers and interfaces that you're utilising.

I asked whether some instruments were better suited to the medium than others: ‘We've worked internationally with world music and really, many, many instruments and voice types that have been on JackTrip and sound amazing. So that's where this software really shines through’.

I described my own experience of attempting to use JackTrip from home installed on my MacBook and not managing to connect to JackTrip servers:

> So that experience is one of the reasons that we got the certification programme up and running, because JackTrip, especially open source, is very difficult to learn just out of the box, so to speak. So especially going through this whole pandemic, where there's a lot of new users in it, we have a lot of volunteer help. But it is something that I think requires training, so there's some fine tuning here to see what's needed.

I asked about using JackTrip in combination with videoconferencing software to achieve audiovisual streaming. Weaver discussed using Zoom, Jitsi, and UltraGrid, but as yet, there is not one single video solution:

> From the early days, Chris [Chafe] was very focussed on audio, and there was a debate in those early days about whether or not even to use video, because audio has its own quality, and video can be distracting, or just another technology challenge that maybe we don't need to do right now. But there is such a demand these days to have visuals going together with the audio that that's a requirement for most performances, at least in the circles I've been involved with. […] we're definitely on the lookout for what may be the companion to JackTrip visually. And honestly, for all these years I have been involved in this medium, that's been the evolving factor. JackTrip for me is the constant, but we've gone through many, many, videoconference systems. It's kind of unresolved.

Thus, despite the advances that the JackTrip technology has made, especially since the start of the pandemic, there is still more work to do to make a single unified audiovisual streaming system.

## 8.6 Discussion

### 8.6.1 Introduction

The pandemic has shown a need for musicians to be able to play together remotely from home. In addition to JackTrip, other low-latency audio-only software programs are available that can operate between homes, and other developers also have standalone devices, such as JamKazam's JamBlaster, and Elk Audio's HiFi Berry. It is likely that in the coming years, more low-

latency audio-only software programs and products will be developed, and there may come a point where just two rival systems vie for dominance, similar to PC/Mac and Android/iOS.

However, at this moment in time, JackTrip has several advantages over other audio-only software programs and since March 2020, five important developments have been implemented to improve usability:

- The JackTrip Foundation have developed a certification programme to assist new users in running the open source version of JackTrip;
- JackTrip has been developed to run on commercial networks requiring only 1–2 Mb, as opposed to a 1 Gb NREN;
- larger music ensembles can now rehearse together from participants' respective homes. In December 2020 this enabled a choir of 53 singers to perform together;
- efforts are being made to further reduce latency on JackTrip utilising cloud-based servers;
- the Virtual Studio version of JackTrip offers a 'plug-and-play' standalone option for users that do not have a technology background, or do not have hardware compatible with the JackTrip program.

These developments present a major advance in remote music learning and teaching but, as yet, synchronous low-latency audiovisual streaming between homes is not possible.

### 8.6.2 Research question 1: What changes in the quality of the interactions and the learning and teaching experience in lessons between face-to-face, standard videoconferencing, and low-latency environments?

JackTrip allowed the participants in Study 15 (Section 8.3) and the vocal teacher in Study 16 (Section 8.4) to play together with students on JackTrip. However, when comparing the hybrid JackTrip system to LoLa, the students in Study 15 preferred LoLa to JackTrip due to having the audio and video in sync, but I found the hybrid system perfectly acceptable for learning and teaching.

This lack of synchronisation between the two elements in the JackTrip hybrid system meant that visual cues could not be given as easily, and the vocal teacher adapted their teaching to suit the medium, giving more audio cues. In some instances in the face-to-face environment, the visual element is less important and used more for peripheral vision, but in other instances, visual cues may be more important, in which case they could be planned more in advance when using JackTrip and Zoom.

Participants reported audio quality being good using JackTrip but missing the natural reverberation and immersive sound of the face-to-face environment. I was very satisfied with the audio quality of JackTrip, and I noticed an improvement compared to videoconferencing.

Pacing of the lessons was also a consideration as the vocal teacher reported being exhausted by teaching with JackTrip, though this is an issue also found when teaching via videoconferencing and LoLa, and teachers learn to adapt to these environments and adjust the pace and structure of lessons accordingly.

### 8.6.3 Research question 2: Are some elements of music instruction more or less effective in these different environments?

Teacher Z noted that ‘low latency is not zero latency, and they will always be fractionally behind’. Until such time as latency is further reduced, face-to-face settings will therefore likely remain the preferred option.

Issues were reported by the vocal teacher in balancing the sound between three different users with different equipment in different acoustic spaces. However, with some training, such as that offered by the JackTrip foundation, it is possible to manipulate the raw audio signal in JackTrip, especially in the open source mode. JackTrip has facilitated collaborations between instrument combinations that would otherwise struggle to perform together in the same acoustic space due to the dominant volume of one instrument, such as bagpipes and saxophone. Furthermore, being able to rehearse with multiple

users in different locations represents a breakthrough in technology, and a choir of 53 singers were able to perform together synchronously using JackTrip.

Thus, JackTrip offers advantages over LoLa in that it can be operated from domestic properties, and it can also facilitate large ensemble rehearsals and performances. JackTrip offers an advantage over videoconferencing as participants can play together due to its low-latency.

### 8.6.4 Research question 3: What are the barriers to using these technologies in educational settings, and how can these be overcome?

From the first JackTrip trial (Study 15, Section 8.3), Student Y voiced concerns about the practical aspects of setting up JackTrip and LoLa technologies in schools. They also commented on the need for low-latency systems to be easy to operate and felt that technical assistance would be required in schools, especially regarding connecting to networks and navigating firewalls. These problems aligned with the experience of the vocal teacher despite them having JackTrip installed on a standalone device. Teacher Z also reported that some students had difficulties connecting their device, though this was thought to be because they did not want to try, and this may in part be attributable to the stress and overwhelm that many students experienced during the pandemic.

Nonetheless, the introduction of inexpensive standalone devices with JackTrip pre-installed improves its usability, especially for users without a technical background, and the JackTrip foundation are developing certificate programmes to train users in JackTrip, particularly the open source version. This addresses two of the issues reported by Brudvik (2018), expense and usability.

Another issue noted by Brudvik (2018) is accessibility, and the ability to use JackTrip on cloud-based servers without having to navigate firewalls dramatically increases access for users. I have made enquiries about using

JackTrip locally, but at the time of writing, the nearest servers are several hundred miles way which would make the latency so great as to defeat the purpose of using JackTrip. However, in time, it is likely that more servers will be added and JackTrip will be accessible to many more users.

### 8.6.5 Final reflections

The findings confirmed the possibility of JackTrip users performing together remotely over a standard commercial network requiring only 1 or 2 Mb data using inexpensive standalone devices. There is a trade-off in the various platforms between the audio quality, ease of use, hardware expense, network and technical requirements, and the number of users that can use the system. By contrast with JackTrip, LoLa requires an expressly specified Windows PC, together with dedicated graphics and sound cards and additional peripheral devices, including a specialist camera and high-speed monitors (Redman, 2020). Furthermore, LoLa requires the use of a high-speed network along with additional support from technical staff to navigate traffic round firewalls (ibid.).

In the early stages of the development of JackTrip, the focus was on achieving high-quality audio with very low latency, and the video element was not seen as a priority. However, since most users also require the video element, JackTrip is often used in combination with videoconferencing platforms, and the problem of adding visuals is recognised as unresolved.

In Section 8.4, Weaver notes a number of factors that affect the latency of the JackTrip system, including the type of server, whether machine-based or cloud-based, and the proximity of the user to the server. There are commercial imperatives for reducing latency and improving the speed and the capacity of the Internet as a whole. Streaming services such as Netflix seek to ensure seamless service for customers, and in financial markets, a fraction of a second can give a financial advantage to traders. Thus, technological advances with the Internet, including the development of cloud-based services, will likely occur from commercial operators which will also benefit musicians.

This chapter has reported on JackTrip technology. By offering low-latency synchronous interaction between multiple users over standard networks, JackTrip offers many interesting new opportunities and this is an exciting and important development for instrumental music teaching at all levels of education. However, there is still some work to do on improving the useability of JackTrip and making it attractive and worthwhile for teachers and students to invest time in learning how to use it.

The following chapter is the conclusion; it provides a summary of answers to the research questions and a discussion on the contribution to knowledge and implications of the research.

# Chapter 9: Conclusion

## 9.1 Introduction

This concluding chapter is organised into six sections: an introduction summarising what is now known at the end of the research; more detailed answers to the research questions; a synthesis of themes emerging from the studies; the contribution to literature made by the research; a discussion of the limitations of the research and possible future research directions; and implications of the research.

This research is born out of my experience as a musician and a teacher with an interest in online learning. Prior to the COVID-19 pandemic, some teachers were sceptical about the use of videoconferencing for instrumental music teaching. This research shows that for many teachers who were converts to teaching via videoconferencing during the pandemic, the experience has been positive, and many are keen to retain some elements of online teaching and videoconferencing in their teaching practice (Chapter 4, Sections 4.3.11 and 4.5.5). However, two fundamental concerns from the early stages of my research into videoconferencing remain: poor audio quality, and not being able to play together. As my research progressed, I became convinced of the need to address these two concerns using low-latency technologies.

Two different types of low-latency technology are examined in this research, LoLa and JackTrip. Since the start of the pandemic, the JackTrip Foundation has rapidly developed JackTrip technology to allow it to operate via home networks using inexpensive standalone devices. This allowed teachers and students to work together from home during the pandemic with high-quality low-latency audio. By contrast, LoLa has not been significantly upgraded over the same time frame. It has the same advantages as pre-pandemic, in offering low-latency, high-quality audio, with synchronous video; however, it also has the same pre-pandemic limitations, in that it still requires an academic network to operate, and also technical assistance to work around

the firewall. Thus, it cannot operate from users' homes, and yet this was precisely what teachers and students were seeking during the pandemic.

The pandemic has caused a massive upheaval throughout societies around the world and, as yet, there is no certainty as to what a 'new normal' will look like. Face-to-face interactions in instrumental music lessons cannot be taken for granted for a variety of reasons, including participants being prevented from meeting in person due to having to self-isolate, or restrictions on travel. In addition, there is an imperative to try to mitigate the effects of travel on climate change. It is therefore important for teachers, students, and educational institutions at all levels, from conservatoires to primary schools, to be aware of the possibilities that now exist to facilitate musical interaction between remote parties.

Based on my research findings, I conclude that videoconferencing platforms such as Zoom or Teams are adequate for many teaching situations, but LoLa offers an experience closer to that of the face-to-face lesson by facilitating synchronous musical interaction. JackTrip also satisfies this fundamental need of many musicians to be able to play together, but without the need for expensive equipment and institutional infrastructure. JackTrip therefore occupies a middle ground between videoconferencing and LoLa and in my view has an important role in the future of music education. The research questions explore these different technologies in relation to the quality of the experience, their effectiveness, and barriers to implementation in educational settings.

## 9.2 Research questions

### 9.2.1 Research question 1: What changes in the quality of the interactions and the learning and teaching experience in lessons between face-to-face, standard videoconferencing, and low-latency environments?

The research presented in Chapters 4 and 5 show that when using standard videoconferencing platforms, the musical experience is affected by a range of

factors including: the quality of the audio and the video capture and how they are reproduced at each end; the acoustic properties of the studios at each location; the stability and bandwidth of the network; and the presence of other parties such as technicians at an institution or family members at a student's home, that may help or hinder the lesson. The establishment of guidance and advice on achieving the optimum technical setup is therefore important for both teachers and students. Given that technology is constantly evolving, this will likely be an area of continuing professional development for teachers.

Teachers reported concerns about potential difficulties with forming relationships with new students via distance learning (Study 1), commenting that it was important to meet students face-to-face prior to commencing lessons via videoconferencing. However, this was not seen as an important factor by experienced videoconferencing teachers, as most felt they were largely able to establish a good rapport with students they had not met face-to-face, and this aligns with my own experience. However, where no visual element is available, it is particularly important for teachers to use a portion of the lesson for social interaction. This is an area that could be more fully investigated in the future and, as with technical setups, guidance could be given to teachers on establishing good rapport with students, and especially with younger students and their families.

From Studies 9–13 in Chapter 6, LoLa was found by participants, including myself, to offer a superior experience compared to standard videoconferencing platforms due to its high-quality audio and the ability to play together. Teachers and students from the SWING teaching trials in conservatoires also reported positive experiences of using LoLa (Study 14, Chapter 7). Many overcame their initial scepticism of the technology and reported being pleasantly surprised once they had used LoLa, particularly with regards to the quality of sound. Teachers also reported that they almost forgot that the student was not present in the same room. The high quality is partly explained by the trials taking place in academic institutions using a high-capacity network, and higher quality microphones and cameras than those built into standard PCs. However, despite the improved experience of LoLa

compared to videoconferencing platforms, the overwhelming view from participants was that the face-to-face experience was still preferable.

A hybrid system was trialled (Chapter 8, Section 8.4) combining the low-latency audio-only program JackTrip with a standard videoconferencing system for the visual element. This hybrid system facilitated synchronous playing with high-quality audio, which also improved the experience compared to standard videoconferencing. Prior to the pandemic, JackTrip required some specialist technical knowledge to set up and it was known as a 'high-quality option, but difficult to operate' (Chapter 8, Section 8.6.2). However, the technology has since been significantly developed to work on standard networks using a plug-and-play device, allowing it to be used between homes. The lack of synchronisation between the audio and video elements with the hybrid JackTrip system may be potentially off-putting to new users, but a participant in the trial, Student Y (Chapter 8, Section 8.3.2), thought it would be possible to adapt to this. As noted by Sarah Weaver (Chapter 8, Section 8.5.2), the video element is an ongoing area of development for JackTrip, and this will likely be an area that receives increased attention in the future.

### 9.2.2 Research question 2: Are some elements of music instruction more or less effective in these different environments?

There are many benefits and disadvantages common to the different systems trialled. Benefits for students include: increased access to specialist music lessons; supplementing principal teacher lessons with additional lessons or masterclasses; convenience of not having to travel for lessons, (e.g. arranging trial lessons when planning to study abroad); ease of recording segments of lessons for review between lessons; more sophisticated technical setups facilitate the ability to view multiple camera angles simultaneously.

Teachers also reported benefits to the change of teaching style as it forced them to plan and prepare more thoroughly and communicate more clearly, which they found also improved their teaching in the face-to-face environment (Study 13, Chapter 6, Section 6.6.7). Teachers were able to view students

taking trial lessons with other teachers, which allowed them to view other teaching styles and methods for their own professional development. Teachers generally found that lessons can be more productive due to less social interaction, and they can also be efficiently scheduled and, where necessary, rescheduled. Some teachers also reported that being physically separate from students benefitted them due to less exposure to loud noise.

Disadvantages include: difficulties resulting from the physical separation in adjusting and diagnosing postural problems and difficulties in adjusting and tuning instruments; fatigue from hyper-focus during the remote lesson; more preparation time required for use of asynchronous resources; some problems with technical equipment resulting in poor audio quality, particularly in the videoconferencing environment; problems with network connections causing interruptions.

By not being physically present in lessons, students also miss out on social elements and the possibility of immersing themselves in different cultures, as discussed in detail by the postgraduate percussion student (Participant L) in Study 2 (Chapter 4, Section 4.3.8). However, videoconferencing has opened up the possibility of lessons to learners who otherwise may not be able to receive instruction due to a variety of factors including geographical location, social circumstances, or more recently, social distancing due to COVID-19.

The findings from Studies 1 and 2 showed that one of the main disadvantages of standard videoconferencing platforms was not being able to play together with students in the remote lesson. This was supported by Study 3 (Chapter 4, Section 4.4) which demonstrated that playing together was the most frequently used intervention in the face-to-face lessons sampled and was also supported by Study 4 (Chapter 4, Section 4.5), in which teachers new to online teaching sought advice for ways to be able to perform together with students. Thus, low-latency technologies, though not yet sufficiently developed for use in every teaching situation, are likely to be a growth area in the future.

Of the audio and visual elements, the audio was considered the most important by participants. Most teachers felt the visual element was also important for various reasons, including observing posture and checking facial expressions that indicated whether students had understood concepts. The LoLa trials (Studies 9 and 10, Chapter 6, Sections 6.2 and 6.3) and the LoLa recording trial (Study 12, Chapter 6, Section 6.5) demonstrated that the greater the visual element was in synchronisation with the audio in the LoLa environment, the more it was used. The JackTrip trial (Study 15, Chapter 8, Section 8.3) and the autoethnographic videoconferencing trials (Studies 6 and 7, Chapter 5, Sections 5.3 and 5.4) showed that it is possible to teach without the visual element, but it does require very clear instructions, and teachers need to adapt their teaching style accordingly. Achieving low-latency synchronous audio and video over standard networks is also likely to be a growth area in the future.

The findings from the LoLa trials (Studies 9–11, Chapter 6, Sections 6.2 to 6.4), the SWING trials (Study 14, Chapter 7, Section 7.2) and JackTrip trial (Study 15, Chapter 8, Section 8.3) demonstrated that LoLa and JackTrip offer an improved experience compared to videoconferencing due to being able to play together with students in the lesson. LoLa is the superior system as it offers synchronised audio and video. JackTrip has other advantages in being able to operate over a standard network with multiple users on inexpensive devices. However, JackTrip also requires a parallel videoconferencing system to be used for the visual element.

### 9.2.3 Research question 3: What are the barriers to using low-latency technologies in educational settings, and how can these be overcome?

Factors that prevent new music technologies being adopted in higher education establishments and schools include attitudes, expense, accessibility, usability (Brudvik, 2018) and reliability. My findings showed that teachers with little or no experience of using these technologies were initially cautious and sceptical. However, teachers using videoconferencing (Study 2, Chapter 4, Section 4.3.11 and Study 4, Chapter 4, Section 4.5.5) and

JackTrip (Study 16, Chapter 8, Section 8.4) during COVID-19 lockdown changed their attitudes, and many found advantages to the technologies which they were keen to retain post-lockdown. A change of attitudes in participants was also found in the SWING trials (Study 14, Chapter 7, Section 7.2.5) where LoLa users reported overcoming their preconceptions and being pleasantly surprised by the quality of the experience.

My own experience of trying to introduce LoLa to the Royal Conservatoire of Scotland showed there was a major obstacle surrounding the issue of bandwidth. I was only given permission to trial the technology at RCS once I had successfully demonstrated that it could be used in compression mode and would therefore only use a fraction of the institution's network bandwidth. Thus, overcoming negative preconceptions and attitudes is an important consideration when introducing new technologies into institutions (Brudvik, 2018) and careful planning is required (Kotter, 1996).

Reliability is another factor connected with attitudes and perceptions. An informal discussion with a director of international studies at a European conservatoire revealed that different international establishments had attempted to use LoLa, but had quickly lost interest when running into technical difficulties regarding networks and firewalls.

Staff that observed the LoLa teaching demonstration (Study 11, Chapter 6, Section 6.4) voiced concerns about the 'usability' of the system, including setting up the equipment themselves. Trials of JackTrip installed on a Raspberry Pi device were discussed in Study 16 (Chapter 8, Section 8.4): teething problems with connecting the technology to a network were reported which caused some students not to persevere with trying to use the technology. Thus, training for staff and students is an important factor when introducing new technologies to institutions, along with having adequate technical support on hand, especially at critical times such as international collaborations between institutions.

Technologies are rarely ‘standalone’. To overcome barriers, they often require supporting technologies such as high-speed networks with specific access points in studios, and also infrastructure support. LoLa requires network technicians to negotiate institutional firewalls, and sound engineers can be helpful to assist in achieving an optimal acoustic environment. Storage of equipment is another factor, along with ease of access to the equipment and also a suitable studio with appropriate internet access. Institutions therefore need to carefully weigh up the costs of the equipment versus the benefits before purchasing LoLa equipment. Yet, without a critical mass of institutions using the technology, early adopters have fewer possible collaborative partners.

The factors of attitudes, expense, accessibility, usability and reliability are often interrelated, but the presence of just one of these factors alone can be enough to prevent implementation of new technologies (Brudvik, 2018). Despite the problems discussed, my view is that low-latency technologies have an important role in the future of music education

## 9.3 A synthesis of themes emerging from the studies

Several themes emerged from a synthesis of findings from the 17 studies presented in Table 1 (Chapter 3, pp.68–72): attitudes, playing together, the importance of the visual element, advantages and disadvantages of each environment, the presence of adults when teaching younger students, and professional development opportunities for teachers.

### 9.3.1 Attitudes play an important factor in the adoption of new technologies

Teachers without prior experience of using videoconferencing for teaching were uncertain about its viability pre-pandemic (Study 1). From the survey of music teacher responses at the beginning of COVID-19 (Study 4), many teachers were surprised at how easily they adapted to online teaching and planned to retain some elements in the future.

Similarly, from the SWING project (Study 14), participants overcame their initial scepticism of LoLa and were impressed by the audio and visual quality of the platform, and the ability to play together in real time.

### 9.3.2 Playing together

The results from the investigation in Study 3 demonstrated that playing together can be an important element of face-to-face lessons. From Study 2, many teachers were frustrated at not being able to play together with students in the videoconferencing environment. The survey of music teacher comments on social media (Study 4) demonstrated the need for an audiovisual system that facilitates playing together, combined with high-quality audio. From the LoLa learning and teaching demonstration (Study 11), the teacher was able to play with students in real time to assist with phrasing, timing, and articulation, and to give commentary during the performance, thus more closely matching the experience of face-to-face lessons than standard videoconferencing platforms.

### 9.3.3 The importance of the visual element

From Study 2, there were mixed views on the importance of the visual element when using videoconferencing. Some teachers felt it was less important than the audio element, and lessons conducted on drum kit in Studies 6 & 7 were successful using audio-only. However, many teachers felt the visual element was essential for checking posture and diagnosing potential physical problems early on (Study 2).

When the audio and video elements were in synchronisation on the LoLa platform, video was used for visual cues (Studies 10 & 12). JackTrip is audio-only, and therefore requires a separate system for the video element and it was recognised that the integration of the visual element remains unresolved (Study 17).

### 9.3.4 Advantages and disadvantages of each environment

Each learning environment had its own advantages and disadvantages, but there were some common themes across all platforms.

Online learning was convenient and avoided participants traveling; it facilitated lessons where face-to-face provision was not available; it broadened the reach of Higher Education, including auditions, masterclasses, trial lessons and supplementary lessons; and it made the sharing of resources easier.

However, online lessons were intensive and tiring due to hyper-focus. More time was required for developing teaching materials, and time in lessons was distributed differently. The loss of physical presence is an ongoing concern across all virtual platforms, and studio environments required planning for different instruments (Studies 13 and 14).

Technical problems such as poor internet connections occasionally caused disruption to lessons when using the videoconferencing platform. The more complex low-latency platforms required more time to learn how to use, and also more time to physically set up the extra equipment such as microphones and monitors.

There was a recognised problem in deploying LoLa technology in institutions, particularly in the initial stages, and the cost of LoLa and the need for a high-bandwidth network and infrastructure may be prohibitively expensive for smaller institutions.

JackTrip has many advantages over other technologies (operating on inexpensive devices via standard networks, and facilitating large ensemble rehearsals and performances) but JackTrip was found to be difficult to operate until users were familiar with it (Study 16), and there was a recognised need for training programmes (Study 17), especially if being deployed in schools (Study 15).

Despite the two younger students in Study 6 making good progress in lessons via videoconferencing, both preferred face-to-face lessons. Similarly, participants in the LoLa and JackTrip trials expressed a preference for learning in person where possible, with online instruction used as a supplement (Studies 13, 14 & 16).

### 9.3.5 Presence of adults when teaching younger students

The presence of adults to assist younger students with setting up technology in remote lessons and accessing online resources was found to be important (Studies 6 & 7). There were concerns about the safeguarding of teachers and students when working from home studios during the pandemic, with conflicting views about whether lessons should be recorded, or parents should be present during remote lessons (Study 4).

### 9.3.6 Professional development opportunities for teachers

Teachers benefitted from professional development opportunities by watching their own students working with other teachers in masterclass settings via videoconferencing (Study 2) and in the LoLa setting (Study 14). There is also a need for pre- and in-service training for teachers in using technologies (Study 4).

## 9.4 Contribution to literature

My research contributes unique findings to the research literature at an important time in the history of music education, spanning the period before and during the COVID-19 pandemic. The findings from the investigation into the frequency with which teachers and students perform together in face-to-face instrumental music lessons (Study 3) gives empirical evidence that playing together can form a significant element of face-to-face instrumental music lessons, an element missing in lessons via standard videoconferencing platforms.

The LoLa trials reported in Chapter 6 (Studies 9–11) demonstrate that LoLa can be used in compression mode with adequate quality for most teaching interactions, with bandwidth requirements between 16 and 33 Mbps, making a modest demand on institutional networks with 1 Gb capacity. An unexpected finding was that LoLa can operate in conjunction with a network firewall, albeit with some degradation of audio quality, something that the LoLa developers maintain is not possible.

The findings from the SWING trials reported in Chapter 7 (Study 14) demonstrate that LoLa can be successfully used for distanced lessons across different instrument disciplines. Crucially, teachers were able to play at the same time as students in lessons to assist with phrasing, timing, and articulation, and to give commentary during a student performance. This confirmed my view that LoLa could more closely match the experience of face-to-face lessons than standard videoconferencing platforms. LoLa also offers new opportunities for synchronous interaction between teachers and students in different institutions, allowing greater opportunities for students to experience a broader range of musical cultures through rehearsing and performing with musicians outwith their own institution.

Data collected from interviews and social media forums since the COVID-19 lockdowns show that online teaching, including videoconferencing, has become much more widely accepted throughout music education. As yet, there is not a simple and widely available option that allows teachers and students to play together remotely.

A key finding from my research shows that JackTrip can operate on inexpensive standalone devices via standard networks. Thus, JackTrip can be used for playing together between domestic properties, something that teachers and students frequently requested during the COVID-19 lockdowns (Study 4, Section 4.5.6). In addition, large ensembles can also rehearse and perform together while in separate locations. JackTrip therefore has the potential to transform musical interactions in the future.

## 9.5 Limitations and future research

Many of the trials were tests of concept and therefore were limited in scope. The LoLa trials I conducted took place on just three separate occasions (Studies 9–11) but showed that LoLa can be used for instrumental music lessons with a relatively low bandwidth requirement. The JackTrip trial (Study 15) was limited, as the opinions of only two participants plus myself were considered, but it did convince me that the hybrid JackTrip/Zoom system was viable. This in turn led to interviews with two experienced practitioners which revealed that JackTrip had been significantly developed since the beginning of the pandemic. The SWING trials offered a selection of experiences on the use of LoLa from a variety of teachers, students, and technicians across three European conservatoires.

To build on this research, further in-depth trials could attempt to find solutions to instrument-specific problems in the online environment. By experimenting with different microphone, camera, monitor, speaker types and placement, and also multiple-camera setups, it should be possible to find the optimum environment for different instrument and genre specific teaching situations. Future trials could investigate new ways of improving the ‘presence’ of remote partners, by experimenting with different acoustic qualities of studios, as well as lighting. Further research could also investigate multi-node teaching situations with LoLa, such as ‘one-to-many’ masterclasses between three institutions. JackTrip also offers many new possibilities for remote teaching with multiple remote sites, and this is likely to be an area of interest for future research.

Each of the remote teaching platforms trialled had some limitations. Based on my findings, my view is that the ideal solution would be a very low-latency platform with fully synchronised high-quality audio and video, inexpensive and easy to use hardware and software, which operates on a standard network without the need for technical support. This is not currently possible, but it may well be possible in the next few years, and this research makes a case for further investigation into these areas of development.

Learning theories and instructional methods that apply to instrumental music teaching online could be explored (Chapter 2, Section 2.2), making use of the added component of online social interaction afforded by online learning. There are opportunities to introduce students to possibilities afforded by 'non-steady-beat music' and Networked Music Performance as discussed by Sarah Weaver (Study 17).

## 9.6 Implications

A growing body of research suggests that the one-to-one lesson, the cornerstone of the conservatoire experience, should be repositioned within a wider context of creative activities that better reflect the professional activities of the 21st century musician (Creech and Gaunt, 2012). Hasikou (2020) argues that due to a combination of rapidly advancing technologies and a shift in pedagogical attitudes, new approaches to one-to-one lessons should be considered in music education. Gaunt and Westerlund (2013) argue for challenging established forms of music education and extending pre-existing realities. The literature suggests that students should not become overly dependent on their teacher in a master-apprentice dyad (Gaunt 2008; Renshaw 2010; Zhukov 2012; Zhukov and Sætre 2021) and Burwell et al. (2019) argue that students should experience input from different teachers. Some literature recommends co-teaching (Clauhs and Newell, 2013; Zanner and Stabb, 2013) and Zhukov and Sætre (2021) describe a 'teaching-through-playing' approach to developing a student's musical and social skills through collaborative chamber music instruction. Thus, low-latency technologies offer conservatoire students greatly expanded possibilities for learning, rehearsing and performing with teachers and students from different institutions, disrupting the traditional master-apprentice model.

To illustrate these new possibilities as they apply to conservatoire students, I will use the percussion family. Percussion students are expected to be versatile in a diverse range of instruments and genres from timpani, through to mallet percussion instruments such as marimba and vibraphone, snare drum, orchestral percussion auxiliary instruments such as cymbals and

tambourine, drum set, and ‘world music’ percussion instruments found in Brazilian samba bands, Japanese Taiko groups, etc. It is not possible for one teacher to be an expert in all areas of percussion, and conservatoires will often bring in specialist performers for masterclasses (Study 2, Chapter 4, Section 4.3.2).

Thus, with the advent of low-latency technologies, conservatoires can easily share specialist teachers with other conservatoires without the expense or disruption associated with travel. Students have the potential to have regular lessons and masterclasses with specialist teachers at other conservatoires. Over the course of a year, students could take specialist modules with expert teachers in, for example, solo marimba, baroque timpani, and jazz vibraphone. Students could form communities of practice and assist in peer learning with students from other conservatoires to share experience and knowledge in these niche disciplines. Teachers could also learn new techniques and teaching methods by observing students being taught by other teachers. Ensembles could be planned on a national basis, rather than being restricted to the availability of performers and equipment in a particular conservatoire, for example creating a marimba orchestra or a vibraphone trio located in several conservatoires.

The wider sharing of knowledge and skills could help to develop and benchmark standards expected when students study at different conservatoires. From the SWING project interview data (Study 14, Chapter 7, Section 7.2.3), a teacher commented on the variation of standards when accepting students from different conservatoires on the Erasmus+ programme, with some exchanges not being successful due to students not being of the expected standard. With wider availability of knowledge and skills beyond the cloistered environment in individual conservatoires, students would be better prepared and more likely to thrive on an exchange visit.

As with conservatoire percussion students, school percussion students have the potential to learn with different teachers, join different ensembles, and be exposed to many more possibilities of musical interaction, including

international collaborations. For example, a student may be learning drum kit, timpani, tuned percussion and snare drum with their main percussion teacher, play in the school wind band and orchestra, but also rehearse in a virtual samba band. Specialist masterclasses could be easily arranged with teachers in neighbouring local authorities, for example, jazz drumming styles, and students could potentially 'sit in' with more advanced ensembles from a different region. Students could also assist each other through peer learning, and teachers also have huge possibilities for professional development.

To take an alternative view, students choose to study at particular conservatoires and universities and to learn from particular teachers due to their reputations, status and kudos. If access to a particular teacher is made more widely available, there may be a perception that institutions lose their special status. There are also implications for the employment of staff, since staff can be sourced not only from outwith a local area, but potentially internationally, as discussed by a jazz guitar teacher (Study 2, Chapter 4, Section 4.3.10).

This also applies in school settings, where teachers can be remote from the school, as in examples in Dumfries and Galloway and North Yorkshire (Huddleston et al. 2007; King et al., 2019). In some respects, this presents a danger for locally employed staff, and as reported in Chapter 1, Section 1.5, teachers were concerned that the adoption of these technologies may 'put us all out of a job'. However, based on the research outcomes described across this thesis, the potentials and possibilities far outweigh any possible downsides.

There are opportunities for teachers to share students, to observe other teaching methods and instrumental techniques, to learn new instruments, and to organise online workshops, rehearsals, and performances. Staff that are willing and motivated to embrace these opportunities are unlikely to be short of employment opportunities. My experience of MOOCs (Study 8, Chapter 5, Section 5.5.3) was that while asynchronous resources can be extremely

useful in supporting learning, students benefit hugely from synchronous personalised interventions from teachers.

Moreover, the COVID-19 pandemic has forced a radical rethink of how instrumental music lessons are delivered in schools. As reported in Chapter 1, Section 1.1, a report by the Scottish Government from 2015 recommended that Local Authorities should explore the opportunities arising from the use of technology (Instrumental Music Implementation Group, Scottish Government, 2015). Despite this recommendation, many Local Authorities in Scotland were previously cautious about using technology, but this changed over the course of a weekend in March 2020 as lockdowns were introduced (Study 7, Chapter 5, Section 5.4.2).

Based on my findings, my view is that in the short term, instrumental music teachers will retain elements of existing videoconferencing/audiovisual streaming where expedient, along with asynchronous resources, in a blend with face-to-face teaching. In the longer term, low-latency technologies will continue to be developed and will likely play an increasingly significant role in remote music teaching. There will be an ongoing need to develop guidelines, protocols, and etiquette for remote teaching, and to train teachers and students in how to maximise the benefits of each type of platform.

This current period of upheaval presents an opportunity for education at all levels to build on improved digital skills, and to rethink how learning is delivered, with far greater emphasis on building the necessary technological framework (better internet access and provision of hardware and software) to improve access and learning opportunities for all students.

# References

ABRSM, 2014. *Making Music: teaching, learning and playing in the UK*. Available at: <https://gb.abrsm.org/media/12032/makingmusic2014.pdf> [Accessed 21 January 2016].

Adams, T.E., Ellis, C. and Jones, S.H., 2017. Autoethnography. In: J. Matthes, C.S. Davis and R.F. Potter, eds. *The International Encyclopedia of Communication Research Methods*, 1st ed. [online] Wiley.pp.1–11. https://doi.org/10.1002/9781118901731.iecrm0011.

AEC, 2019. *SWING: Synergic Work Incoming New Goals for Higher Education Music Institutions*. [online] Available at: <https://www.aec-music.eu/projects/current-projects/swing-2018---2021> [Accessed 1 December 2019].

AEC, 2021. *About AEC*. [online]. Available at: <https://aec-music.eu/about-aec/> [Accessed 21 July 2021].

Anderson, L., 2006. Analytic autoethnography. *Journal of Contemporary Ethnography*, 35(4), pp.373–395.

Andrews, R., 2011. Does e-learning require a new theory of learning? Some initial thoughts. *Journal for Educational Research Online/Journal für Bildungsforschung Online*, 3(1), pp.104–121.

Angen, M., 2000. Evaluating interpretive inquiry: reviewing the validity debate and opening the dialogue. *Qual Health Res*, 10(3), pp.378–95. https://doi.org/10.1177/104973230001000308.

Antonini Philippe, R., Schwab, L. and Biasutti, M., 2021. Effects of Physical Activity and Mindfulness on Resilience and Depression During the First Wave of COVID-19 Pandemic. *Frontiers in Psychology*, 12, p.700742. https://doi.org/10.3389/fpsyg.2021.700742.

Aultman, J., 2020. Utilizing a Concurrent Nested Design for Strengthening Mixed Methods Research. In: *SAGE Research Methods Cases: Medicine and Health*. [online] London: SAGE Publications. https://doi.org/10.4135/9781529715859.

Azevedo, J.P., Hasan, A., Goldemberg, D., Iqbal, S.A. and Geven, K., 2020. *Simulating the Potential Impacts of COVID-19 School Closures on Schooling and Learning Outcomes: A Set of Global Estimates*. [online] World Bank, Washington, DC. https://doi.org/10.1596/1813-9450-9284.

Baines, P., 2021. *Universities must swap physical for digital estates − at warp speed*. [online] Times Higher Education. Available at: <https://www.timeshighereducation.com/opinion/universities-must-swap-physical-digital-estates-warp-speed> [Accessed 7 February 2021].

Bauer, W.I., 2014. *Music learning today: digital pedagogy for creating, performing, and responding to music*. New York: Oxford University Press.

Betzl, J., Kraneburg, U. and Megerle, K., 2020. Overuse syndrome of the hand and wrist in musicians: a systematic review. *Journal of Hand Surgery (European Volume)*, 45(6), p.7.

Biasutti, M., Antonini Philippe, R. and Schiavio, A., 2021. Assessing teachers' perspectives on giving music lessons remotely during the COVID-19 lockdown period. *Musicae Scientiae*, p.102986492199603. https://doi.org/10.1177/1029864921996033.

Bochner, A. and Ellis, C., 1996. Talking over ethnography. In: A. Bochner and C. Ellis, eds. *Composing Ethnography: Alternative Forms of Qualitative Writing*. Walnut Creek, CA: Alta Mira Press.

Bowman, J., 2014. *Online Learning in Music: Foundations, Frameworks and Practices*. Oxford: Oxford University Press.

Broad, S., Hunter, K., Moscardini, L., Rae, A., Smillie, G. and Wilson, A., 2019. *What's Going On Now?* Glasgow, United Kingdom: Royal Conservatoire of Scotland.

Brook, J. and Upitis, R., 2015. Can an online tool support contemporary independent music teaching and learning? *Music Education Research*, 17(1), pp.34–47. https://doi.org/10.1080/14613808.2014.969217.

Brudvik, S., 2018. *What's stopping you?: A multiple case study of impediments to incorporating music technology in Norwegian schools*. Master's Thesis. Høgskulen p\a a Vestlandet/Western Norway University of Applied Sciences.

Bubb, S. and Jones, M.-A., 2020. Learning from the COVID-19 home-schooling experience: Listening to pupils, parents/carers and teachers. *Improving Schools*, 23(3), pp.209–222. https://doi.org/10.1177/1365480220958797.

Bulmer, M., 2008. The ethics of social research. In: G.N. Gilbert, ed. *Researching social life*, 3rd ed. Los Angeles: Sage.

Burwell, K., 2012. *Studio-Based Instrumental Learning*. SEMPRE Studies in the Psychology of Music. Farnham: Ashgate.

Burwell, K., 2013. Apprenticeship in music: A contextual study for instrumental teaching and learning. *International Journal of Music Education*, 31(3), pp.276–291.

Burwell, K., Carey, G. and Bennett, D., 2017. Isolation in studio music teaching: The secret garden. *Arts and Humanities in Higher Education*, p.1474022217736581.

Burwell, K., Carey, G. and Bennett, D., 2019. Isolation in studio music teaching: The secret garden. *Arts and Humanities in Higher Education*, 18(4), pp.372–394. https://doi.org/10.1177/1474022217736581.

Buzan, S. and Whitehead, M.-T., 2021. *Moving Communication and Collaboration Online: Making Changes for Home-based Learning with Kotter's 8-Step Process*. Master's Thesis. Tampere University of Applied Sciences.

Byrne, C. and MacDonald, R.A.R., 2002. The Use of Information; Communication Technology in the Scottish Music Curriculum: A focus group investigation of themes and issues. *Music Education Research*, 4(2), pp.263–273. https://doi.org/10.1080/1461380022000011957.

Cáceres, J.-P. and Chafe, C., 2010. JackTrip: Under the Hood of an Engine for Network Audio. *Journal of New Music Research*, 39(3), pp.183–187. https://doi.org/10.1080/09298215.2010.481361.

Cáceres, J.-P., Hamilton, R., Iyer, D., Chafe, C. and Wang, G., 2008. To the edge with China: Explorations in network performance. In: *ARTECH 2008: Proceedings of the 4th International Conference on Digital Arts*. pp.61–66.

Carr-Chellman, A., 2021. *Let's stop confusing what just happened with true online learning*. [online] THE Campus. Available at: <https://www.timeshighereducation.com/campus/lets-stop-confusing-what-just-happened-true-online-learning> [Accessed 12 June 2021].

Carter, C.S., 2014. Oxytocin Pathways and the Evolution of Human Behavior. *Annual Review of Psychology*, 65(1), pp.17–39. https://doi.org/10.1146/annurev-psych-010213-115110.

Cauberghe, V., Van Wesenbeeck, I., De Jans, S., Hudders, L. and Ponnet, K., 2020. How Adolescents Use Social Media to Cope with Feelings of Loneliness and Anxiety During COVID-19 Lockdown. *Cyberpsychology, Behavior, and Social Networking*. [online] https://doi.org/10.1089/cyber.2020.0478.

Chafe, C., Cáceres, J.-P. and Gurevich, M., 2010. Effect of temporal separation on synchronization in rhythmic performance. *Perception*, 39(7), pp.982–992. https://doi.org/10.1068/p6465.

Chafe, C., Gurevich, M., Leslie, G. and Tyan, S., 2004. Effect of time delay on ensemble accuracy. In: *Proceedings of the International Symposium on Musical Acoustics*. [online] Available at: <https://ccrma.stanford.edu/~cc/pub/pdf/ensAcc.pdf> [Accessed 13 December 2015].

Chafe, C. and Oshiro, S., 2019. Jacktrip on Raspberry Pi. In: *Proceedings of the 17th Linux Audio Conference (LAC-19)*. CCRMA, Stanford University, USA.p.4.

Chang, H., 2016. *Autoethnography as method*. Abingdon/New York: Routledge.

Clauhs, M. and Newell, M.K., 2013. Co-learning and Co-teaching to Promote Change: A Response to the Housewright Declaration in a North American Undergraduate Music Education Programme. In: H. Gaunt and H. Westerlund, eds. *Collaborative learning in higher music education*, SEMPRE studies in the psychology of music. Farnham, Surrey; Burlington, VT: Ashgate.

Clements, A., 2018. A Postdigital Future for Music Education: Definitions, Implications, and Questions. *Action, Criticism, and Theory for Music Education*, 17(1), pp.48–80.

Coe, R., 2017. The nature of educational research. In: R. Coe, M. Waring, L. Hedges and J. Arthur, eds. *Research Methods and Methodologies in Education*, 2nd edition. London: Sage Publications Ltd.

Colwell, R., 2011. Roles of Direct Instruction, Critical Thinking, and Transfer in the Design of Curriculum for Music Learning. In: R. Colwell and P.R. Webster, eds. *MENC Handbook of Research on Music Learning: Volume 1: Strategies*.

[online] USA: Oxford University Press. Available at: <http://www.oxfordscholarship.com/view/10.1093/acprof:osobl/9780195386677.001.0001/acprof-9780195386677> [Accessed 24 January 2016].

Contavespi, V., 1998. *Picture this*. [online] Forbes. Available at: <https://www.forbes.com/1998/03/11/feat.html> [Accessed 9 March 2021].

Cowling, J., 2016. *A Brief History of Skype - the peer to peer messaging service*. [online] Available at: <https://content.dsp.co.uk/history-of-skype> [Accessed 25 May 2021].

Creech, A., 2010. Learning a musical instrument: the case for parental support. *Music Education Research*, 12(1), pp.13–32. https://doi.org/10.1080/14613800903569237.

Creech, A. and Gaunt, H., 2012. The Changing Face of Individual Instrumental Tuition: Value, Purpose, and Potential. In: G.E. McPherson and G.F. Welch, eds. *The Oxford Handbook of Music Education, Volume 1*. [online] Oxford University Press. pp.693–711. https://doi.org/10.1093/oxfordhb/9780199730810.013.0042.

Creech, A. and Hallam, S., 2009. Interaction in instrumental learning: the influence of interpersonal dynamics on parents. *International Journal of Music Education*, 27(2), pp.94–106. https://doi.org/10.1177/0255761409102318.

Črnčec, R., Wilson, S.J. and Prior, M., 2006. The Cognitive and Academic Benefits of Music to Children: Facts and fiction. *Educational Psychology*, 26(4), pp.579–594. https://doi.org/10.1080/01443410500342542.

Dammers, R.J., 2009. Utilizing Internet-Based Videoconferencing for Instrumental Music Lessons. *Update: Applications of Research in Music Education*, 28(1), pp.17–24. https://doi.org/10.1177/8755123309344159.

Daubney, A. and Fautley, M., 2020. Editorial Research: Music education in a time of pandemic. *British Journal of Music Education*, 37(2), pp.107–114. https://doi.org/10.1017/S0265051720000133.

Davidson, J.W. and Borthwick, S.J., 2002. Family Dynamics and Family Scripts: A Case Study of Musical Development. *Psychology of Music*, 30, pp.121–136.

Davies, G., 2015. *The effectiveness of LOLA (LOw LAtency) audiovisual streaming technology for distributed music practice*. Masters by Research. Edinburgh Napier University.

Delamont, S., 2009. The only honest thing: Autoethnography, reflexivity and small crises in fieldwork. *Ethnography and Education*, 4(1), pp.51–63.

Department for Education, 2011. *The Importance of Music, A National Plan for Music Education*. [online] Available at: <https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/180973/DFE-00086-2011.pdf> [Accessed 24 January 2016].

Dessen, M., 2020. *Networked music performance: An introduction for musicians and educators*. [online] Medium.com. Available at: <https://mdessen.medium.com/networked-music-performance-an-introduction-for-musicians-and-educators-d31d33716bd2> [Accessed 23 March 2021].

Diep, F., 2020. *Rethinking Campus Spaces*. [online] The Chronicle of Higher Education. Available at: <https://store.chronicle.com/collections/reports-guides/products/rethinking-campus-spaces>.

Downes, S., 2020. Recent Work in Connectivism. *European Journal of Open, Distance and E-Learning*, 22(2), pp.113–132. https://doi.org/10.2478/eurodl-2019-0014.

Drever, E., 1995. *Using Semi-Structured Interviews in Small-Scale Research: A Teacher's Guide*. Edinburgh: Scottish Council for Research in Education (SCRE).

Drioli, C., Allocchio, C. and Buso, N., 2013. Networked performances and natural interaction via LOLA: Low latency high quality A/V streaming system. In: *Information Technologies for Performing Arts, Media Access, and Entertainment*. [online] Springer.pp.240–250. Available at: <http://link.springer.com/chapter/10.1007/978-3-642-40050-6_21> [Accessed 13 December 2015].

Duffy, C., 2016. ICON: Radical professional development in the conservatoire. *Arts and Humanities in Higher Education*, 15(3–4), pp.376–385. https://doi.org/10.1177/1474022216647385.

Duffy, S. and Healey, P., 2017. A new medium for remote music tuition. *Journal of Music, Technology and Education*, 10(1), pp.5–29. https://doi.org/10.1386/jmte.10.1.5_1.

Dye, K., 2016. Student and instructor behaviors in online music lessons: An exploratory study. *International Journal of Music Education*, 34(2), pp.161–170.

Ellis, C., Adams, T. and Bochner, A., 2010. Autoethnography: An Overview. *Qualitative Social Research / Sozialforschung*. Available at: <http://nbn-resolving.de/urn:nbn:de:0114-fqs1101108> [Accessed 17 December 2020].

Esperanza, P., Fabian, K. and Toto, C., 2016. Flipped Classroom Model: Effects on Performance, Attitudes and Perceptions in High School Algebra. In: K. Verbert, M. Sharples and T. Klobučar, eds. *Adaptive and Adaptable Learning*. [online] Cham: Springer International Publishing.pp.85–97. Available at: <http://link.springer.com/10.1007/978-3-319-45153-4_7> [Accessed 4 October 2016].

European Commission, 2020. *What is Erasmus+?* [online] Erasmus+. Available at: <https://ec.europa.eu/programmes/erasmus-plus/about_en> [Accessed 1 September 2020].

Facebook, 2020. *Terms of Service*. [online] Available at: <https://www.facebook.com/terms.php> [Accessed 1 April 2020].

Federation of Music Services and National Association of Music Educators, 2002. *A Common Approach 2002*. Harlow: Faber.

Ferguson, P., Chafe, C. and Gapp, S., 2020. Trans-Europe Express Audio: testing 1000 mile low-latency uncompressed audio between Edinburgh and Berlin using GPS-derived word clock, first with jacktrip then with Dante. *Audio Engineering Society Convention e-Brief 605* p.5. Available at: <https://www.aes.org/e-lib/browse.cfm?elib=20843> [Accessed 02 October 2020].

Fleming, J., 2018. Recognizing and resolving the challenges of being an insider researcher in work-integrated learning. *International Journal of Work-Integrated Learning, Special Issue*, 19(3), p.10.

Forster, E.M., 1909/2011. *The Machine Stops*. Modern Classics. London: Penguin Books Limited.

Frazes Hill, C., 2008. A Portfolio Model for Music Educators. *Music Educators Journal*, 95(1), pp.61–72. https://doi.org/10.1177/0027432108318481.

Future Learn, 2020. *What is a MOOC?* [online] Available at: <https://www.futurelearn.com/info/blog/what-is-a-mooc-futurelearn> [Accessed 29 December 2020].

Gabrielsson, 2000. Timing in music performance and its relations to music. In: J.A. Sloboda, ed. *Generative Processes in Music*. Oxford: Oxford University Press.

Gall, M., 2017. TPACK and Music Teacher Education. In: A. King, E. Himonides and A. Ruthmann, eds. *The Routledge Companion to Music, Technology, and Education*. Abingdon/New York: Routledge. pp.305–318.

Garcia, M., 2020. An Overview of Innovations in Online Learning. In: B. Panth and R. Maclean, eds. *Anticipating and Preparing for Emerging Skills and Jobs: Key Issues, Concerns, and Prospects*, Education in the Asia-Pacific Region: Issues, Concerns and Prospects. [online] Singapore: Springer Singapore. https://doi.org/10.1007/978-981-15-7018-6.

Gaunt, H., 2008. One-to-one tuition in a conservatoire: the perceptions of instrumental and vocal teachers. *Psychology of Music*, 36(2), pp.215–245. https://doi.org/10.1177/0305735607080827.

Gaunt, H., 2010. One-to-one tuition in a conservatoire: the perceptions of instrumental and vocal students. *Psychology of Music*, 38(2), pp.178–208. https://doi.org/10.1177/0305735609339467.

Gaunt, H., López-Íñiguez, G. and Creech, A., 2021. Musical engagement in one-to-one contexts. In: A. Creech, D. Hodges and S. Hallam, eds. *Routledge International Handbook of Music Psychology in Education and the Community*. London and New York: Routledge.

Gaunt, H. and Westerlund, H., 2013. Prelude: The Case for Collaborative Learning in Higher Music Education. In: H. Gaunt and H. Westerlund, eds. *Collaborative learning in higher music education*, SEMPRE studies in the psychology of music. Farnham, Surrey; Burlington, VT: Ashgate.

Green, L., 2002. *How popular musicians learn: a way ahead for music education*. Ashgate popular and folk music series. Aldershot, Hants; Burlington, VT: Ashgate.

Green, L., 2008. *Music, informal learning and the school: a new classroom pedagogy*. Ashgate popular and folk music series. Farnham: Ashgate.

Greenberg, D. and Gordon, I., 2020. *Lockdown singing: the science of why music helps us connect in isolation*. [online] The Conversation. Available at: <https://theconversation.com/lockdown-singing-the-science-of-why-music-helps-us-connect-in-isolation-137312> [Accessed 2 May 2020].

Gregory, S. and Renshaw, P., 2013. *Creative Learning across the Barbican-Guildhall Campus A new paradigm for engaging with the arts?* Guildhall School of Music & Drama.

Gurevich, M., Chafe, C., Leslie, G. and Tyan, S., 2004. Simulation of networked ensemble performance with varying time delays: Characterization of ensemble accuracy. In: *Proceedings of the 2004 International Computer Music Conference, Miami, USA*. [online] Available at: <http://michaelgurevich.com/media/gurevich_ICMC04.pdf> [Accessed 13 December 2015].

Hadhazy, A., 2020. *Stanford-developed software enables musicians isolated by the coronavirus pandemic to jam together again in real-time*. [online] Stanford News. Available at: <https://news.stanford.edu/2020/09/18/jacktrip-software-allows-musicians-sync-performances-online/> [Accessed 1 February 2021].

Hallam, S., 1998. *Instrumental teaching: a practical guide to better teaching and learning*. Oxford: Heinemann Educational.

Hallam, S., 2010. The power of music: Its impact on the intellectual, social and personal development of children and young people. *International Journal of Music Education*, 28(3), pp.269–289. https://doi.org/10.1177/0255761410370658.

Hallam, S., 2015. *The power of music.* London: iMERC.

Harasim, L.M., 2012. *Learning theory and online technology*. New York, NY: Routledge.

Harland, J., Kinder, K., Lord, P., Stott, A., Schagen, I., Haynes, J., Cusworth, L., White, R. and Paola, R., 2000. *Arts education in secondary schools: effects and effectiveness*. Slough, Berkshire: National Foundation for Educational Research.

Harris, P., 2012. *The virtuoso teacher: the inspirational guide for intrumental and singing teachers*. London: Faber Music.

Harris, P. and Crozier, R., 2000. *The music teacher's companion: a practical guide*. London: Associated Board of the Royal Schools of Music.

Hash, P.M., 2021. Remote Learning in School Bands During the COVID-19 Shutdown. *Journal of Research in Music Education*, 68(4), p.18.

Hasikou, A., 2020. New Approaches to Individual Instrumental Tuition in Music Education. *Athens Journal of Education*, 7(2), pp.193–202. https://doi.org/10.30958/aje.7-2-4.

Huddleston, P., Muir, F., Mills, J., Duffy, C. and Watt, T., 2007. *Evaluation of the Instrumental Tuition by Video Conferencing Project*. University of Warwick: Centre for Education and Industry.

Instrumental Music Implementation Group, Scottish Government, 2015. *Instrumental Music Tuition in Scotland*. Edinburgh.

Iorwerth, M. and Knox, D., 2019. Playing Together, Apart: Musicians' Experiences of Physical Separation in a Classical Recording Session. *Music Perception: An Interdisciplinary Journal*, 36(3), pp.289–299. https://doi.org/10.1525/mp.2019.36.3.289.

Iorwerth, M., Moore, D. and Knox, D., 2015. Challenges of using Networked Music Performance in education. In: *UK 26th Conference: Audio Education (August 2015)*. p.5.

JackTrip Foundation, 2021a. *JackTrip Virtual Studio*. [online] Available at: <https://www.jacktrip.org/studio.html> [Accessed 21 February 2021].

JackTrip Foundation, 2021b. *Why is Latency Important?* [online] JackTrip Technology. Available at: <https://www.jacktrip.org/technology.html> [Accessed 15 May 2021].

Jenkins, 2011. Formal and Informal Music Educational Practices. *Philosophy of Music Education Review*, 19(2), p.179. https://doi.org/10.2979/philmusieducrevi.19.2.179.

Johnson, C., 2017. Teaching music online: Changing pedagogical approach when moving to the online environment. *London Review of Education*, 15(3), pp.439–456. https://doi.org/10.18546/LRE.15.3.08.

Johnson, C., 2020. A conceptual model for teaching music online. *International Journal on Innovations in Online Education*. [online] https://doi.org/10.1615/IntJInnovOnlineEdu.2020035128.

Johnson, C., 2021. A Historical Study (2007-2015) on the Adoption of Online Music Courses in the United States. *International Journal on Innovations in Online Education*. [online] https://doi.org/10.1615/IntJInnovOnlineEdu.2021037316.

Kim, L.E. and Asbury, K., 2020. 'Like a rug had been pulled from under you': The impact of COVID-19 on teachers in England during the first six weeks of the UK lockdown. *British Journal of Educational Psychology*, 90(4), pp.1062–1083. https://doi.org/10.1111/bjep.12381.

King, A., Prior, H. and Waddington-Jones, C., 2019. Connect Resound: Using online technology to deliver music education to remote communities. *Journal of Music, Technology & Education*, 12(2), pp.201–217. https://doi.org/10.1386/jmte_00006_1.

King, N., 2016. *Template Analysis: Themes and codes*. [online] Themes and codes. Available at: <http://www.hud.ac.uk/hhs/research/template-analysis/technique/themes-and-codes/> [Accessed 4 November 2016].

Kirschner, S. and Tomasello, M., 2009. Joint drumming: Social context facilitates synchronization in preschool children. *Journal of Experimental Child Psychology*, 102(3), pp.299–314. https://doi.org/10.1016/j.jecp.2008.07.005.

Koehler, M.J. and Mishra, P., 2009. What is Technological Pedagogical Content Knowledge? *Contemporary Issues in Technology and Teacher Education*, 9(1), p.11.

Kokotsaki, D., 2016. Pupils' attitudes to school and music at the start of secondary school. *Educational Studies*, 42(2), pp.201–220. https://doi.org/10.1080/03055698.2016.1160822.

Kokotsaki, D. and Hallam, S., 2011. The perceived benefits of participative music making for non-music university students: a comparison with music students. *Music Education Research*, 13(2), pp.149–172. https://doi.org/10.1080/14613808.2011.577768.

Kotapish, P., 2020. *Ragazzi Boys Chorus Leaps Into the Future With Virtual Studio*. [online] San Francisco Classical Voice. Available at: <https://www.sfcv.org/music-news/ragazzi-boys-chorus-leaps-into-the-future-with-virtual-studio> [Accessed 28 February 2021].

Kotter, J., 1996. *Leading change*. Boston, Mass.: Harvard Business School Press.

Koutsoupidou, T., 2014. Online distance learning and music training: benefits, drawbacks and challenges. *Open Learning: The Journal of Open, Distance and e-Learning*, 29(3), pp.243–255. https://doi.org/10.1080/02680513.2015.1011112.

Kruse, N.B., Harlos, S.C., Callahan, R.M. and Herring, M.L., 2013. Skype music lessons in the academy: Intersections of music education, applied music and technology. *Journal of Music, Technology and Education*, 6(1), pp.43–60. https://doi.org/10.1386/jmte.6.1.43_1.

Kruse, N.B. and Veblen, K.K., 2012. Music teaching and learning online: Considering YouTube instructional videos. *Journal of Music, Technology and Education*, 5(1), pp.77–87. https://doi.org/10.1386/jmte.5.1.77_1.

Lamba, P., 2011. Teleconferencing in Medical Education: A Useful Tool. *Australasian Medical Journal*, 4(8), pp.442–447. https://doi.org/10.4066/AMJ.2011.823.

Levinsen, K., Ørngreen, R. and Buhl, M., 2013. Telepresence as Educational Practice in the Third Teaching-Room: A Study in Higher Music Education. In: M. Ciussi and M. Augier, eds. *Proceedings of the 12th European Conference of E-learning*. Sonning Common: Academic Conferences and Publishing International. pp.250–257.

Levinsen, K., Ørngreen, R., Buhl, M., Jakobsen, M.L. and Andersen, J., 2011. Instrumental Distance Learning in Higher Music Education. 10th European Conference on e-learning (ECEL 2011). Academic Conferences and Publishing International. pp.993–996.

Ley, B., 2004. The art of teaching in groups. In: A. Marks, ed. *All together! Teaching music in groups*. London, UK: ABRSM.

Lincoln, Y.S. and Guba, E.G., 1985. *Naturalistic Inquiry*. Newbury Park, CA.: SAGE Publications.

López-Íñiguez, G. and Coutts, L., 2020. Embracing a learner identity: An Autoethnographic duet exploring disruptive critical incidents in instrumental music pedagogy. *Proceedings of the 23rd International Seminar of the ISME Commission on the Education of the Professional Musician (CEPROM)*, p.22.

MacDonald, R., Kreutz, G. and Mitchell, L., 2012. What is Music, Health and Wellbeing and Why is It Important? In: R. MacDonald, G. Kreutz and L. Mitchell, eds. *Music, Health and Wellbeing*. Oxford: Oxford University Press.

MacDonald, R.A.R., Hargreaves, D.J. and Miell, D. eds., 2017. *Handbook of Musical Identities*. Oxford: Oxford University Press.

Maidlow, S., 1998. The Experiences, Attitudes and Expectations of Music Students from a Feminist Perspective. *British Journal of Music Education*, 15(1), pp.37–49. https://doi.org/10.1017/S0265051700003752.

Markee, N., 2012. Emic and Etic in Qualitative Research. In: *The Encyclopedia of Applied Linguistics*. [online] Wiley-Blackwell. https://doi.org/10.1002/9781405198431.wbeal0366.

Marshall, C. and Rossman, G.B., 1999. *Designing qualitative research*. 3rd ed. Newbury Park, CA.: SAGE Publications, Inc.

Maxner, R., 2021. Starting and teaching beginner piano students online. *Starting and teaching beginner piano students online*. Available at: <https://rebekah.maxner.ca/2021/01/04/starting-and-teaching-beginner-piano-students-online/> [Accessed 4 January 2021].

Meier, F., Fink, M. and Zolzer, U., 2014. The JamBerry - A Stand-Alone Device for Networked Music Performance Based on the Raspberry Pi. [online] Linux Audio Conference. p.9. Available at: <http://lac.linuxaudio.org/2014/papers/6.pdf.>.

Mills, J., 2005. *Music in the school*. Oxford: Oxford University Press.

Mills, J., 2007. *Instrumental teaching*. Oxford: Oxford University Press.

Minguella, M. and Buchanan, C., 2009. *The Use of Music as a Tool for Social Inclusion. Research Report for Cork City Council*.

Mithen, S., 2009. The Music Instinct: The Evolutionary Basis of Musicality. *Annals of the New York Academy of Sciences*, 1169(1), pp.3–12. https://doi.org/10.1111/j.1749-6632.2009.04590.x.

Mizuno, M., 2012. Asian Network Music Performances with Jacktrip. In: *Asia Computer Music Project 2012*. [online] ACMP 2012, Taiwan. Taiwan.p.4. Available at: <http://www.acmp.asia/acmp2012papers/acmp2012_submission_7.pdf>.

Moore, J.L., Dickson-Deane, C. and Galyen, K., 2011. e-Learning, online learning, and distance learning environments: Are they the same? *The Internet and Higher Education*, 14(2), pp.129–135. https://doi.org/10.1016/j.iheduc.2010.10.001.

MSM, 2021. *Distance Learning History*. [online] Manhattan School of Music Distance Learning History. Available at: <https://www.msmnyc.edu/programs/distance-learning/history/> [Accessed 1 August 2021].

Nordlof, J., 2014. Vygotsky, Scaffolding, and the Role of Theory in Writing Center Work. *The Writing Center Journal*, 34(1).

Norman, R. and Volpe, C., 2021. *LoLa, music without borders times three*. [online] Connect Online. Available at: <https://connect.geant.org/2021/01/04/lola-music-without-borders-times-three> [Accessed 4 January 2021].

Nusseck, M. and Spahn, C., 2021. Musical Practice in Music Students During COVID-19 Lockdown. *Frontiers in Psychology*, 12, p.643177. https://doi.org/10.3389/fpsyg.2021.643177.

OECD, 2020. *The impact of COVID-19 on student equity and inclusion: Supporting vulnerable students during school closures and school re-openings*. OECD Policy Responses to Coronavirus (COVID-19). [OECD

Policy Responses to Coronavirus (COVID-19)] https://doi.org/10.1787/d593b5c8-en.

O'Hara, G., 2020. Universities are on the brink of crisis. Coronavirus may tip them over the edge. *The Guardian*. [online] 21 May. Available at: <https://www.theguardian.com/commentisfree/2020/may/21/universities-brink-crisis-coronavirus-pandemic-tuition-fees?CMP=share_btn_tw> [Accessed 21 May 2020].

Orr, J., 2020. *A brief history of video conferencing*. [online] Allwork. Available at: <https://allwork.space/2020/11/a-brief-history-of-video-conferencing/> [Accessed 25 May 2021].

Parry, J., 2020. *Flexible working: lessons from the great work-from-home mass experiment*. [online] The Conversation. Available at: <https://theconversation.com/flexible-working-lessons-from-the-great-work-from-home-mass-experiment-152268> [Accessed 19 December 2020].

Pouthas, V., 1996. The development of the perception of time and temporal regulation of action in infants and children. In: I. Deliege and J.A. Sloboda, eds. *Musical Beginnings: Origins and Development of Musical Competence*. Oxford: Oxford University Press.

Prior, H., Mackay, R. and King, A., 2015. Digital delivery of instrumental lessons in remote rural areas. In: *Ninth Triennial Conference of the European Society for the Cognitive Sciences of Music*. Manchester, UK.

Rasch, R.A., 2000. Timing and synchronisation in ensemble performance. In: J.A. Sloboda, ed. *Generative Processes in Music*. Oxford: Oxford University Press.

Redman, B., 2020. The potential of videoconferencing and low-latency (LoLa) technology for instrumental music teaching. *Music & Practice*, [online] 6. https://doi.org/10.32063/0610.

Reed-Danahay, D., 1997. Introduction. In: D. Reed-Danahay, ed. *Auto/ethnography: Rewriting the self and the social*. Abingdon, New York: Routledge.

Renshaw, P., 2010. *Engaged passions: searches for quality in community contexts*. Delft: Eburon.

Renshaw, P., 2013. Postlude: Collaborative Learning: A Catalyst for Organizational Development in Higher Music Education. In: H. Gaunt and H. Westerlund, eds. *Collaborative learning in higher music education*, SEMPRE studies in the psychology of music. Farnham, Surrey; Burlington, VT: Ashgate.

Rife, N.A., Shnek, Z.M., Lauby, J.L. and Lapidus, L.B., 2001. Children's Satisfaction with Private Music Lessons. *Journal of Research in Music Education*, 49(1), pp.21–32. https://doi.org/10.2307/3345807.

Riley, H., MacLeod, R.B. and Libera, M., 2014. Low Latency Audio Video: Potentials for Collaborative Music Making Through Distance Learning. *Update: Applications of Research in Music Education*, p.8755123314554403.

Ritchie, L. and Sharpe, B., 2021. Music Student's Approach to the Forced Use of Remote Performance Assessments. *Frontiers in Psychology*, 12, p.9.

Robson, C., 2002. *Real world research: a resource for social scientists and practitioner-researchers*. Oxford: Blackwell.

Rockschool, 2021. *Rockschool Drums*. [online] Rockschool Contemporary Graded Music Exams. Available at: <https://www.rslawards.com/rockschool/graded-exams/drums/> [Accessed 1 July 2021].

Rofe, M. and Reuben, F., 2017. Telematic performance and the challenge of latency. *Journal of Music, Technology and Education*, 10(2), pp.167–183. https://doi.org/10.1386/jmte.10.2-3.167_1.

Rottondi, C., Chafe, C., Allocchio, C. and Sarti, A., 2016. An Overview on Networked Music Performance Technologies. *IEEE Access*, 4, pp.8823–8843. https://doi.org/10.1109/ACCESS.2016.2628440.

Ruffini, G., 2009. Presence and reality. In: D. Benyon, M. Smyth and I. Helgason, eds. *Presence for everyone: a short guide to presence research*. Edinburgh, UK: Centre for Interaction Design, Edinburgh Napier University.

Ruszkiewicz, J.J., Walker, J.R. and Pemberton, M.A., 2006. *Bookmarks: a guide to research and writing*. 3rd ed. New York: Longman.

Ruthmann, A. and Herbert, D., 2012. Music learning and new media in virtual and online environments. In: G. McPherson and G. Welch, eds. *The Oxford Handbook of Music Education*. Oxford: Oxford University Press.

Sánchez Cabrero, R. and Costa Román, Ó., 2018. Psychopedagogical Predecessors of Connectivism as a New Paradigm of Learning. *International Journal of Educational Excellence*, 4(2), pp.29–45. https://doi.org/10.18562/IJEE.037.

Sapolsky, R., 2016. *To Understand Facebook, Study Capgras Syndrome*. [online] Nautilus. Available at: <https://nautil.us/issue/42/fakes/to-understand-facebook-study-capgras-syndrome> [Accessed 1 April 2017].

Shah, D., 2020. *By The Numbers: MOOCs in 2020*. [online] The Report, by Class Central. Available at: <https://www.classcentral.com/report/mooc-stats-2020/> [Accessed 29 December 2020].

Shoemaker, K. and van Stam, G., 2010. *ePiano, a case of music education via internet in rural Zambia*. [online] Available at: <http://journal.webscience.org/340/> [Accessed 13 December 2015].

Siebenaler, D.J., 1997. Analysis of Teacher-Student Interactions in the Piano Lessons of Adults and Children. *Journal of Research in Music Education*, 45(1), pp.6–20. https://doi.org/10.2307/3345462.

Siemens, G., 2005. Connectivism: A Learning Theory for the Digital Age. *International Journal of Instructional Technology and Distance Learning*, 2(1), p.9.

Simones, L.L., 2015. Beyond expectations in music performance modules in higher education: rethinking instrumental and vocal music pedagogy for the twenty-first century. *Music Education Research*, pp.1–11. https://doi.org/10.1080/14613808.2015.1122750.

Simpson, M. and Tuson, J., 1995. *Using Observations in Small-Scale Research: A Beginner's Guide*. Edinburgh: Scottish Council for Research in Education.

Singh, E., 2014. Learning theory and online technologies. *Open Learning: The Journal of Open, Distance and e-Learning*, 29(1), pp.89–92. https://doi.org/10.1080/02680513.2013.864550.

SmartMusic, 2021. *SmartMusic*. [online] Available at: <https://www.smartmusic.com> [Accessed 1 July 2021].

Steels, L. ed., 2015. *Music learning with massive open online courses (MOOCs)*. Future of learning. Amsterdam; Washington, DC: IOS Press.

Stevens, L.H., 2008. *Method of movement for marimba*. 25th Anniversary ed. Asbury Park, New Jersey: Keyboard Percussion Publications.

Stinton, N., 2020. The Surprising Benefits of Asynchronicity: Teaching Music Theatre Online. *Australian Voice*, 21, p.8.

Susino, M., 2020. Promising practices in music teaching and learning: practical recommendations and policies across cultures. *Arts Education Policy Review*, pp.1–11. https://doi.org/10.1080/10632913.2020.1844831.

Swanwick, K., 1996. Instrumental teaching as music teaching. In: G. Spruce, ed. *Teaching music*. London: Routledge in association with the Open University.

Taetle, L. and Cutietta, R., 2002. Learning theories as roots of current musical practice and research. In: R. Colwell and C. Richardson, eds. *The new handbook of research on music teaching and learning*. New York: Oxford University Press.pp.279–298.

Thorgersen, K.A. and Mars, A., 2021. A pandemic as the mother of invention? Collegial online collaboration to cope with the COVID-19 pandemic. *Music Education Research*, pp.1–16. https://doi.org/10.1080/14613808.2021.1906216.

Townsend, L. and Wallace, C., 2016. *Social Media Research: A Guide to Ethics*. Available at: <https://www.gla.ac.uk/media/Media_487729_smxx.pdf> [Accessed 1 April 2020].

Trahar, S., 2009. *Beyond the story itself: Narrative inquiry and autoethnography in intercultural research in higher education*. [online] Qualitative Social Research / Sozialforschung. Available at: <http://nbn-resolving.de/urn:nbn:de:0114-fqs0901308> [Accessed 30 December 2020].

Trollinger, V.L. and Sataloff, R.T., 2018. It's All about the Voice . . . for Wind Instrumentalists, Too! *Music Educators Journal*, 105(2), pp.36–42. https://doi.org/10.1177/0027432118803430.

Tsioutas, K. and Xylomenos, G., 2021. Assessing the QoME of NMP via Audio Analysis Tools. *Proceedings of the 18th International Conference on Signal Processing and Multimedia Applications, SIGMAP 2021*. p.7.

Ubik, S., Navratil, J., Melnikov, J., Goo, B., Mohd Noor, F.N., Baumann, A., Hrb, J., Allocchio, C. and Castillo, G., 2016. Cyber performances, technical

and artistic collaboration across continents. *Future Generation Computer Systems*, 54, pp.306–312. https://doi.org/10.1016/j.future.2015.06.009.

Underhill, J., 2020. *The heart of the school is missing. Music education in the COVID-19 crisis*. [online] Incorporated Society of Musicians. Available at: <https://www.ism.org/images/files/ISM_UK-Music-Teachers-survey-report_Dec-2020_A4_ONLINE-2.pdf> [Accessed 7 December 2020].

Upitis, R., Várela, W. and Abrami, P.C., 2013. Enriching the Time Between Music Lessons with a Digital Learning Portfolio. *Canadian Music Educator*, p.8.

Waldron, J., 2009. Exploring a virtual music community of practice: Informal music learning on the Internet. *Journal of Music, Technology and Education*, Volume 2,(Numbers 2-3), pp.97–112.

Waldron, J., 2012a. Conceptual frameworks, theoretical models and the role of YouTube: Investigating informal music learning and teaching in online music community. *Journal of Music, Technology and Education*, 4(2), pp.189–200. https://doi.org/10.1386/jmte.4.2-3.189_1.

Waldron, J., 2012b. YouTube, fanvids, forums, vlogs and blogs: Informal music learning in a convergent on-and offline music community. *International Journal of Music Education*, pp.91–105.

Ward, F., 2019. Technology and the transmission of tradition: An exploration of the virtual pedagogies in the Online Academy of Irish Music. *Journal of Music, Technology and Education*, 12(1), pp.5–23. https://doi.org/10.1386/jmte.12.1.5_1.

Wardrobe, K., 2020. *Dear Music Teachers: You Can't Run A Live Rehearsal Online (So Here's What To Do Instead)*. Available at: <https://midnightmusic.com.au/2020/04/dear-music-teachers-you-cant-run-a-live-rehearsal-online/> [Accessed 28 February 2021].

Waring, M., 2017. Finding your theoretical position. In: R. Coe, M. Waring, L. Hedges and J. Arthur, eds. *Research Methods and Methodologies in Education*, 2nd edition. London: Sage Publications Ltd.

Waterfield, J., 2018. Convenience Sampling. In: B.B. Frey, ed. *The SAGE Encyclopedia of Educational Research, Measurement, and Evaluation*. [online] Thousand Oaks, California: SAGE Publications, Inc. https://doi.org/10.4135/9781506326139.

Watson, K., 2014. *Learning to teach online: Why is online teaching important?* Available at: <http://bit.ly/coursera-ltto> [Accessed 28 July 2014].

Webster, P.R., 2002. Computer-based technology and music teaching and learning. In: R. Colwell and C. Richardson, eds. *The New Handbook of Research on Music Teaching and Learning: a Project of the Music Educators National Conference*. pp.416–439.

Welch, G., Hallam, S., Lamont, A., Swanwick, K., Green, L., Hennessy, S., Cox, G., O'Neill, S. and Farrell, G., 2004. Mapping music education research in the UK. *Psychology of Music*, 32(3), pp.239–290.

Welch, G., Saunders, J. and Himonides, E., 2014. An evaluation of children's instrumental learning in the Every Child a Musician (ECaM) programme. In: *25th International Seminar on Research in Music Education*. [online] pp.321–335. Available at: <http://www.researchgate.net/profile/Graham_Welch/publication/268078038_An_evaluation_of_childrens_instrumental_learning_in_the_Every_Child_a_Musician_(ECaM)_programme/links/546135660cf27487b4526fe4.pdf> [Accessed 24 January 2016].

Welch, G., Saunders, J., Himonides, E. and Purves, R., 2013. *Every Child a Musician: Project Evaluation 2011-2012*. [online] London: London Borough of Newham. Available at: <http://www.researchgate.net/profile/Graham_Welch/publication/268078265_

Every_Child_a_Musician_Project_Evaluation_2011-2012/links/5461450d0cf27487b452715b.pdf> [Accessed 24 January 2016].

Wenger, E., McDermott, R. and Snyder, W., 2002. *Cultivating communities of practice*. Boston, MA: Harvard Business School Press.

Wise, S., Greenwood, J. and Davis, N., 2011. Teachers' use of digital technology in secondary music education: illustrations of changing classrooms. *British Journal of Music Education*, 28(2), pp.117–134. https://doi.org/10.1017/S0265051711000039.

Yarbrough, C., 1992. Observational Research. In: A. Kemp, ed. *Some Approaches to Research in Music Education*. Reading, England: International Society for Music Education, ISME International Office.

Zanner, A. and Stabb, D., 2013. Singers, Actors and Classroom Dynamics: From Co-teaching to Co-learning. In: H. Gaunt and H. Westerlund, eds. *Collaborative learning in higher music education*, SEMPRE studies in the psychology of music. Farnham, Surrey; Burlington, VT: Ashgate.

Zeltsman, N., 2003. *Four-Mallet Marimba Playing: A Musical Approach for All Levels*. Milwaukee, WI: Hal Leonard.

Zhao, Y., 2020. COVID-19 as a catalyst for educational change. *PROSPECTS*, 49(1–2), pp.29–33. https://doi.org/10.1007/s11125-020-09477-y.

Zhukov, K., 2007. Student learning styles in advanced instrumental music lessons. *Music Education Research*, 9(1), pp.111–127. https://doi.org/10.1080/14613800601127585.

Zhukov, K., 2012. Teaching strategies and gender in higher education instrumental studios. *International Journal of Music Education*, 30(1), pp.32–45. https://doi.org/10.1177/0255761411431392.

Zhukov, K. and Sætre, J.H., 2021. “Play with me”: Student perspectives on collaborative chamber music instruction. *Research Studies in Music Education*, p.1321103X2097480. https://doi.org/10.1177/1321103X20974804.

# Appendices

## Appendix A: Participant Information Sheet

**Pilot project: technology-mediated instrumental music teaching in schools**

Dear ……

I am an instrumental music teacher and a part-time research student at the Royal Conservatoire of Scotland. I am researching the use of technology in instrumental music lessons in schools. I am interested in a broad range of technologies used in instrumental teaching, including the use of audio and video recording equipment in lessons, smart phone and tablet apps, online YouTube clips, videoconferencing, online Virtual Learning Environments such as GLOW, and online portfolios. I am hoping that the research may eventually inform the development and delivery of instrumental music teaching in schools in Scotland.

I would be grateful for the opportunity to conduct an interview with you about your use of technology in your teaching practice, and how your pupils respond to this. The process will take approximately 30 minutes and would be at a time and place of your choosing.

Ethical approval for this research has been granted by the Royal Conservatoire of Scotland. Participation is entirely voluntary, you are free to decline to take part, to leave the process at any time, and to ask for any data given to be returned to you and destroyed. The interview will be recorded on a portable device and I will also take notes, all of which will be stored securely. After I have transcribed parts of the recording it will be destroyed with no copies kept. All the information you give will be anonymous. I will also send you a copy of my notes from the interview to give you the opportunity to change, delete, or comment further on any parts. The results will be presented in writing and may be given in oral presentations as part of the research degree.

Taking part in the research will not give you any direct benefit, though it may in time influence policy and decision making in instrumental music teaching. I do not anticipate any risks in you taking part in the research.

If you would be willing to participate, please contact me at: b.redman@rcs.ac.uk to arrange a suitable time and date for the interview.

Thank you in advance.

Kind regards,

Ben Redman

# Appendix B: Participant Informed Consent Form

**Researcher: Benjamin Redman**

Please tick as applicable

1. I confirm that I have read and understand the Participant Information Sheet for the above study. I have had the opportunity to consider the information, ask questions and have had these answered satisfactorily. ☐

2. I understand that my participation is voluntary; that I am free to withdraw at any time, without giving any reason; that there is no financial benefit to taking part. ☐

3. I understand that any information given by me in relation to the research may be included in reports, published academic papers, theses, and presentations. ☐

4. I understand that my details will remain anonymous in the research and that any information that is confidential will remain so. ☐

5. I understand that all data will be stored securely and is covered by the Data Protection Act. ☐

For the purposes of the above research:

6. I give my consent for the researcher to interview me. ☐

7. I give my consent for the researcher to record the interview. ☐

| _____ | _____ | _____ |
|---|---|---|
| (Name of participant) | (Date) | (Signature) |
| Ben Redman | | |
| _____ | _____ | _____ |
| (Name of researcher) | (Date) | (Signature) |

(One copy of this Informed Consent Form will remain with the researcher. The other copy will be handed to the participant for their own records).

## Appendix C: Interview framework - Initial study of instrumental music teacher attitudes

Pilot project: technology-mediated instrumental music teaching in schools

Interview framework 16th March 2015

- Please tell me about the type of school you teach in, the instruments you teach and the age range of pupils.
- Which technologies are you currently using in your lessons?
- What are your reasons for using these, and in what way do you think these are helping your pupils?
- How are your pupils responding to the technologies?
- Do you think pupil progress is improving using these technologies, and if so, are you able to measure this?
- Do you notice any improvement in pupils' motivation and co-operation when using technologies?
- Are there any aspects of the face-to-face lesson that you feel are essential, and would be difficult to be replaced by using technology?
- Are there any other technologies you would be interested in trying?
- Do you have any experience of videoconferencing and if so, what are your thoughts on that?
- What ideas do you have for future developments?

## Appendix D: Interview framework - Survey of experienced videoconferencing teachers and students

Interview framework 07/05/2021

- Can you briefly tell me about the students you have taught via videoconferencing with regard to age and level of experience?
- Can you tell me about the different types of videoconferencing software you have used?
- What instrument specific problems have you encountered as a string teacher?
- How have you coped with adjusting posture and tuning instruments?
- During COVID, could you tell me about problems and successes you have had with pupils when teaching online?
- Have you missed being able to play at the same time as students?
- How has your teaching strategy changed when teaching online?
- What strategies have you used for adding bow marks and notating a student's music?
- What do you feel might help those students who dropped out engage with online lessons?
- Has your experience prompted you to think about different or new ways of teaching?
- What are your thoughts on seeing and hearing what the student is playing?
- What are your thoughts on building and maintaining a rapport between teacher and student when online?

Technical questions

- Could you tell me about your experience of using videoconferencing with regards to the following:
- Audio quality
- Video quality
- Stability of internet connections
- File sharing (recordings, PDFs of sheet music, if appropriate)
- What technological advances do you feel would improve the experience of teaching via videoconferencing? For example:
    - Faster and more reliable internet connections
    - Bigger screen
    - Multiple camera views
    - Low-latency videoconferencing

## Appendix E: SWING Evaluation Concept

# SWING Evaluation Concept

*AEC contact person: Stefan Gies*

The project description as confirmed by the Italian Erasmus Agency through funding commitment, assigns the following evaluation tasks to AEC:

- to develop criteria for the evaluation of the Strategic Partnership;
- to identify an external expert to visit one project activity a year, read through materials and write an annual evaluation report.

Due to the significance, but also the scope of the tasks and duties arising from the SWING project, the SWING consortium decided at its first transnational meeting, which took place on 26 and 27 November 2018 at the Conservatorio G. Tartini in Trieste, that the evaluation tasks to be chaired and supervised by AEC shall be carried out in three sets of measures:

- Set of Measures #1: Feedback interviews with project participants
- Set of Measures #2: An External expert's report on technical aspects
- Set of Measures #3: Mapping and monitoring research projects on remote learning in Higher Music (Performance) Education.

## *Set of Measures #1: Feedback interviews with project participants*

Short description and goal:

The set of measures #1 will be implemented and carried out in collaboration with the AEC SMS ("Strengthening Music in Society") Working Group No. 5 (Learning & Teaching).[1] As part of this set of measures, selected project participants (representing teachers, students, technicians) are interviewed individually and in different stages of the project, and input is gathered from them on their expectations, experiences and assessments about project progress and project outcomes. This will be done through surveys as well as through face-to-face interviews. The key tool of this set of measures is guided, semi-open interviews.

The interviews are expected to support project participants' reflection on the project's aims and benefits and to contribute to systematically record individual experiences which the participants gather in their work with the LOLA system as part of the SWING project. However, the interviews should also provide information on

[1] The term of the AEC project "Strengthening Music in Society" (SMS) lasts from 1 December 2017 to 30 November 2021 and thus covers the entire duration of the SWING project (01.09.2018 - 31.08.2021).

the pros and cons, weaknesses and strengths of remote learning in general and the LOLA system in particular. They are moreover expected to provide valuable hints how to further develop the system with regard to educational and didactic, but also technical and legal aspects. The interviews will be transcribed and at least partially documented and systematically evaluated using methods of empirical social research.

Organisation:

Each of the three project partners (Ljubljana, Trieste, Vienna) is assigned one to two supervisors, who are as a rule recruited out of the members of the SMS L&T WG. Each project partner appoints 4 to 6 project participants as interviewees. Out of these, at least one interviewee per institution must represent one of the three group of a) teachers, b) students, c) technicians. Initial contacts between the interviewer and the interviewee are based on a questionnaire. In the second phase, a face-to-face interview takes place on-site, which takes place whenever feasible before or after the interviewer's participation in a remote teaching session of the interviewee. The interview series is accomplished by another interview, either face-to-face or Skype.

Timetable (provisional):

| | | |
|---|---|---|
| by 31 May 2019 | • Appointment of the responsible project manager for the respective locations<br>• Preparation of a standardised questionnaire for contacting the interviewees<br>• Designation of interviewees | SMS WG L&T<br><br>SMS WG L&T / AEC<br><br>Project partners |
| by 31 July 2019 | • Execution of questionnaire-based interviews | SMS WG L&T |
| by 15 Sept 2019 | • Evaluation of questionnaire-based interviews<br>• Finalising a mind map as the basis for the guided interviews | SMS WG L&T / AEC<br>SMS WG L&T |
| 15 Sept to 31 Dec 2019 | • Execution of the guided interviews on site | SMS WG L&T |
| by 31Jan 2020 | • Short report on the first interim results of the interviews, so that they can be included in the SWING project half-term report | SMS WG L&T / SWING consortium |
| by September 30, 2020 | • Transcription and evaluation of the interviews | AEC |

## *Set of Measures #2: An External expert's report on technical aspects*

Short description and goal:

The set of measures #2 will be carried out as an external review carried out by an independent expert that will be nominated by the AEC. The subject of the investigation are the hardware and software used. The investigation will address the question of whether these meet the necessary requirements in order to make sure that the objectives described in the project proposal can be achieved. The expert writes an interim report, which should include recommendations for actions to take during the further course of the project, as well as a final report. The expert's assessment will be based on a list of questions provided by the AEC to support completing an external evaluators' task as part of a strategic partnership or cooperation project. *(see attachment)*

Organisation:

The process of selecting an expert will be carried out by the AEC which is also the decision-making instance. The project consortium will be involved in the selection process. All official project documents are med accessible to the expert. The technicians involved in the project are available to answer questions and give feedback to the expert. Moreover, the opportunity is given to the expert to attend a multiplier event or a working group meeting or to pay an on-site visit to one of the participating partner institutions at least once in the calendar years 2019, 2020 and 2021.

Timetable (provisional):

| | | |
|---|---|---|
| by 30 June 2019 | • Selection and appointment of an external expert | AEC / SWING Consortium |
| by 15 Feb 2020 | • Submission of an interim report | External Expert |
| by 31 Jan 2022 | • Submission of the final report | External Expert |

## *Set of Measures #3: Mapping and monitoring research projects on remote learning in Higher Music (Performance) Education.*

Short description and goal:

There are a number of research projects, most of them doctoral thesis projects, dealing with remote online learning based on the use of tailor-made software and

hardware. Some of these projects also specifically address the LOLA system used in the SWING project.

Activities under the set of measures #3 focus on didactic aspects of working with remote systems in the field of music performance learning and teaching in higher music education.

Organisation (provisional):

As part of the set of measures #3, it is initially intended to look out for and contact relevant research projects. As a next step, the landscape will be mapped, which also includes detailed data on the respective research projects' objectives. In the further course, an expert meeting (doctoral colloquium) will be organised in cooperation with the AEC SMS WG L&T, in which representatives of research projects will have the opportunity to exchange experiences with each other directly.

Timetable (provisional):

| | | |
|---|---|---|
| from April 2019 on: | • Gathering suitable research projects, possibly supported by a targeted call | SMS WG L&T / AEC |
| by 30 Sept 2019 | • Creating an online platform for the exchange of experiences and ideas among each other | SMS WG L&T / AEC |
| 2020 | • Organizing an expert meeting (doctoral colloquium) in cooperation with the AEC SMS WG L&T | SMS WG L&T / AEC |

## Appendix F: SWING Project Initial Questionnaire

| | | |
|---|---|---|
| Date | | |

| | | |
|---|---|---|
| Name | | |
| Institution | | |
| Role / function | ❑ Student ❑ Teacher<br>❑ Technician *(please tick as appropriate)* | |
| Instrument (if applicable) | | |
| Teaching discipline (for teachers) | | |
| Study program (for students) | | |

| A 1. Please describe your previous experience in using online systems for musical interaction and / or instrumental / vocal lessons: |
|---|
| |

| A 2. If you already have experience with LOLA or comparable systems: Indicate up to three aspects that you have noticed as particularly positively or negatively: | |
|---|---|
| **+** | |
| **+** | |
| **+** | |
| **-** | |
| **-** | |
| **-** | |

| A 3. What do you think are the most important differences between the traditional instrument lesson (face to face) and the one with the LOLA setting? |
|---|
| |

| A 4. What do you think are the most important differences between the traditional Erasmus experience and an Erasmus experience supported by a LOLA setting? |
|---|

| |
|---|
| |

| A 5. What made you decide to participate in the SWING project? |
|---|
| |

| A 6. What are your expectations with regard to this project? |
|---|
| |

B. Please answer the following questions by entering any value ranging between 0 (maximum disagreement / no) and 10 (maximum agreement / yes):

| B 1. I enjoy using digital devices such as computers, smartphones etc. | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| | | | | | | | | | | |

| B 2. I tend to make use of new technical means quite shortly after they are available on the market - I'm an early adopter |
|---|

| 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | |

| B 3. Traditional music education makes too little use of the opportunities new technologies can offer | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| | | | | | | | | | | |

| B 4. Traditional instrumental or vocal teaching makes too little use of the opportunities new technologies can offer | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| | | | | | | | | | | |

| B 5. The quality of the latest audio systems is so excellent that there is really no difference anymore compared to a live performance | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| | | | | | | | | | | |

| B 6. Systems like LOLA are suitable for rehearsals and teaching, but will never be a serious alternative to musical interaction in a real physical space | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| | | | | | | | | | | |

| B 7. Systems as LOLA are suitable to improve observing and reflecting one's own music performance and practicing | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| | | | | | | | | | | |

# Appendix G: Letter of consent for using SWING project interview data

Association Européenne des Conservatoires, Académies de Musique et Musikhochschulen

Association Européenne des Conservatoires,
Académies de Musique et Musikhochschulen (AEC)
Avenue des Celtes/Keltenlaan 20
1040 Etterbeek, Brussels, Belgium
E: info@aec-music.eu
T: +32 27 37 16 70
www.aec-music.eu

Brussels, 20 April 2020

**To whom it may concern**

I herewith declare in my capacity as chair of the SWING evaluation project group commissioned to monitor and evaluate the Erasmus plus Strategic Partnership Project *Synergic Work Incoming New Goals for Higher Education Music Institutions* (SWING) which was approved and granted in 2018 by the Italian governmental body *Agenzia Nazionale Erasmus Plus Indire* under the project number, 2018-1-IT02-KA203-048546 and carried out under the leadership of *Consorzio GARR*, that the interviews with project participants carried out within the project may be used by third parties for research purposes in a version of the transcriptions of these interviews that is authorised by me in my capacity as chair of the SWING evaluation group. This includes the right to publish under certain conditions excerpts from these interviews.

The above mentioned conditions are met in particular if the anonymisation rules as confirmed vis-à-vis the interviewees are followed. These rules include that

- all the participants' details will be anonymised, and no names discussed in the interviews will be used;
- the participants will only be identified by their instrument and status as teacher, student, or technician; only the country in which the interview took place will be referred to, not the city or institution;
- acknowledgement and credit are given to the SWING project and the AEC for providing access to the interview data.

In particular, I hereby give permission to Mr. Benjamin Redman to use the data gathered as part of the SWING evaluation interviews for his PhD dissertation and any presentations and journal articles that may follow on from this. Mr. Redman committed to refer to each interview participant with a code, e.g. A1 = Austria, 1st interviewee; S3 = Slovenia, 3rd interviewee, etc.

I hereby also declare that each individual interviewee was asked whether, in compliance with the conditions described in more detail above, she or he consents to the use of the data in the above-mentioned sense. The consent was declared in each individual case as part of the interviews.

With best regards,

Stefan Gies
AEC Chief Executive Officer

# Appendix H: Full table of participants

| Code | Participant details | Setting | Base country | Date | Duration of interview |
|---|---|---|---|---|---|
| **A** | Percussion teacher | Private school, ages 5–18 | UK | 02/05/2015 | 28:13 |
| **B** | Guitar teacher | Secondary | UK | 23/05/2015 | 18:36 |
| **C** | Upper strings teacher | Primary and secondary | UK | 19/05/2015 | 18:04 |
| **D** | Keyboard teacher | Primary, secondary and special needs | UK | 14/05/2015 | 22:58 |
| **E1** | Brass teacher | Primary and secondary via videoconferencing | UK | 27/05/2015 | 14:28 |
| **E2** | Brass teacher | Primary and secondary via videoconferencing | UK | 12/12/2015 | 22:17 |
| **F** | Cello teacher | HEMI and private | UK | 24/03/2016 | 18:59 |
| **G** | Jazz guitar teacher | HEMI and private | Canada | 06/04/2016 | 31:19 |
| **H** | Music lecturer | HEMI | UK | 13/04/2016 | 27:11 |
| **I** | Jazz piano teacher | Private | UK | 02/07/2018 | 33:14 |
| **J** | Piping teacher | HEMI | UK | 26/11/2017 | 17:24 |
| **K** | Cello student/teacher | HEMI | UK | 12/06/2020 | 24:54 |
| **L** | Postgraduate percussion student | HEMI and study in India | USA | 05/03/2020 | 12:25 |
| **M** | Percussion teacher | HEMI | USA | 23/11/2019 | 01:13:05 |
| **N** | Percussion teacher | HEMI | USA | 04/12/2019 | 25:26 |
| **O** | Music lecturer | HEMI | Brazil | 15/02/2016 | 27:34 |
| **P** | String teacher | Primary and secondary school | UK | 07/05/2021 | 38:31 |
| **Q** | Beginner percussion student | Private | UK | N/A | N/A |
| **R** | Beginner percussion student | Private | UK | N/A | N/A |
| **S** | Parent of students Q & R | Private school, ages 5–18, HEMI, private | UK | 12/05/2018 | 41:13 |
| **T** | Saxophonist | HEMI | UK | 01/09/2017 | N/A |
| **U** | Head of Guitar and Harp at RCS | HEMI | UK | 10/09/2019 | N/A |
| **V** | Guitar student | HEMI | UK | 10/09/2019 | N/A |
| **W** | Guitar student | HEMI | UK | 10/09/2019 | N/A |
| **X** | Percussion student | HEMI | UK | 17/02/20 | 12:48 |
| **Y** | Postgraduate student | HEMI | UK | 19/02/20 | 18:47 |
| **Z** | Vocal teacher | HEMI | USA | 19/12/2020 | 35:05 |
| | Justin Trieger | HEMI, Director of Distance Learning | USA | 16/12/2019 | 37:19 |
| | Sarah Weaver | HEMI, Network Arts | USA | 19/2/2021 | 58:16 |

*Table 8: Full table of participants*