Australian studies of videoconference and video-assisted instrumental music teaching: What have we learned?

Alan Anderson
University of New England, Australia

Maria Northcote
Avondale College of Higher Education, Australia

Abstract

Technological advances in digital video and videoconference technology around the early 2000s led a number of researchers to investigate the practicalities of using videoconferencing technology for instrumental music teaching in online and blended learning contexts. Technical and instructional strategies were developed and recommendations made concerning the use of desktop video and videoconferencing technology for instrumental music teaching. As a first step in examining the take up and refinement of such strategies and the extent to which research and practice in this field has advanced, this article presents a review of music education literature in conjunction with educational technology literature, with a particular focus on school and tertiary education settings in Australia. Past and present themes are compared in addressing the question: How are desktop video and videoconference-mediated instrumental music teaching strategies being integrated in school and tertiary education settings in Australia?

Technological and pedagogical developments are identified along with remaining challenges. Recommendations are made for further research and development of new models for using videoconferencing and video technologies in conjunction with other learning technologies. These recommendations have implications for on-campus and online education in the context of schools and tertiary colleges.

Key words: Music Education, Instrumental, Video, Videoconference, Online, Distance Education

Introduction

Turn of the millennium expectations of ICT-assisted learning

The early 2000s heralded a wave of technological advances that inspired researchers to investigate the plausibility of using videoconferencing technology for music teaching. Amid signs of more ubiquitous and higher speed computer networks to come (The New Media Consortium, 2004; Whateley & Russell, 1997) researchers in music education investigated the affordances of videoconferencing for music teaching and learning (Anderson & Ellis, 2001; Anderson & Fitzgerald, 2007; Gordon, Rees, & Leong, 2000; Maki, 2001).

The perceived benefits of these technological advances were expected to extend beyond solutions for distance education (Brace-Govan & Clulow, 2000; Postle et al., 2003; Whateley & Russell, 1997). In fact, for some researchers, the term 'distance learning' was reaching its use-by date as online learning promised to improve access for all learners irrespective of location. Instead, terms such as blended learning, hybrid learning, integrated learning, flexible learning and e-learning were appearing and continue to be used today (Broadbent, 2017; Gaskell & Mills, 2015; Owston & York, 2018; Stacey & Gerbic, 2008). Demand for 'flexible learning' was growing across multiple sectors of education, work and training (Australian National Training Authority, 2000) along with calls for new technological and pedagogical principles and practices that could best leverage the possibilities of new Information

and Communications Technology (ICT) (Edwards, Webb, & Murphy, 2000).

Early online learning design and delivery governed by constraints of the technology

Early endeavours in online teaching, especially in higher education settings, often utilised asynchronous communication tools such as discussion boards hosting "asynchronous discussion groups" (Postle et al., 2003, p. 45) more than synchronous videoconferencing. Asynchronous communication was sometimes used to provide flexibility for students and teachers communicating at different times across different time zones, but technical constraints could also be an inhibiting factor. For example, bandwidth limitations meant that certain synchronous and multimedia-rich virtual classroom tools could be prone to slow performance if more than a few users wished to simultaneously interact using video and webcam conferencing features. This problem was magnified for those with low-speed, dial-up modem connections to the Internet. Such constraints could be problematic for music teachers accustomed to hearing their students perform a piece live, after which the teacher may provide immediate verbal feedback and perhaps give an impromptu demonstration to reinforce points about good performance technique. These constraints also severely limited the size of digital video files that could be uploaded or streamed over the Internet (Anderson & Ellis, 2001, 2005).

The promise of more fluid videoconferencing and video-assisted learning over faster networks was therefore seen as a means to improve access for distance learners and those in need of more flexible delivery. In theory, the most appropriate blend of synchronous and asynchronous communication tools could now be deployed based on a 'fit-for-purpose' basis rather than working around technical constraints of the day. In addition, growth in the power and storage capacity of personal computers appeared set to continue at an exponential rate, thus providing unprecedented flexibility to produce and distribute comprehensive and customisable instructional video resources via the Internet.

Evolving technology-assisted music teaching and learning resources

Whilst tutor books for learning musical instruments have traditionally been designed for the teacher and student to work through together (e.g. Bay, 1980), it is widely acknowledged that performance skills develop largely in proportion to the amount and quality of self-directed practice and performance activity the student engages in between lessons (Chaffin, 2011; Powell, 1984; St George, 1990; Turner, 2013). Accordingly, many contemporary music learning resources are designed to be largely self-contained and help develop the student's music literacy and instrumental performance skills simultaneously. For example, recordings of selected exercises performed by expert musicians may be provided for the student to play along with or use as a point of reference while reading corresponding musical notation and instructions.

Despite many advances in technology and changing formats, for example, from vinyl records to audio cassette, audio Compact Disc (CD), Podcast, Vodcast and Digital Versatile Disc (DVD), audio learning resources have remained relevant for music teaching and learning. This is because listening to and playing or singing along with audio recordings is a recognised method for improving aural perception and, in turn, the development of music performance skills (Weigert, 1997).

Although audio-visual formats have not replaced the need for audio resources, it is relevant to note that video offers some benefits that audio cannot. Video can be produced to show musical instrument performance technique in slow-motion and simultaneously at different angles within different windows. This is significant because observing

ideal performance technique can help students to learn, compare and correct their technique where necessary. Furthermore, developing optimal performance technique is important not only for best possible sound production but to minimise risk of musculoskeletal injury through sustained practice using awkward technique and posture (Bellisle & Decker, 2017; Brandfonbrener, 1995; Brodsky, 1995; Newman, 1994).

The advent of relatively low-cost webcam video and conferencing technology during the 1990s inspired many music educators and researchers to explore the possibilities of producing their own instructional videos for teaching online. Some researchers investigated how these technologies could be used to enhance music teaching and learning into the future. Anderson and Ellis (2001, 2005), for example, investigated technical and pedagogical strategies for teaching musical instruments in online, blended and videoconference-supported learning contexts. These studies concluded that "to implement desktop video assisted music teaching and learning effectively, teachers need a range of technical and pedagogical skills beyond those traditionally considered core to the practice of music teaching" (Anderson & Ellis, 2005, p. 915). Studies investigating the use of larger commercial room-based videoconference systems for teaching music arrived at similar conclusions, especially concerning the need for students and teachers to adapt and develop new pedagogical and technological skills where applicable (Anderson & Ellis, 2001; Anderson & Fitzgerald, 2007; Gordon et al., 2000; Maki, 2001).

Commercial and DIY resource production for music teaching and learning

Media companies adapted to the shift from analogue to digital video by converting previously popular instructional video titles from VHS and BETA tape to new formats such as Digital Versatile Discs (DVD) or for distribution via websites and apps on mobile learning devices. Typically, such music instruction videos feature internationally acclaimed performers whose reputation or virtuosity in playing a particular instrument or style of music precedes them (DCI Music Video Productions, 1983, 1990).

In contrast, the advent of lower budget, consumer-level desktop video and webcam technology empowered consumers (Wales, 2000) including music teachers, to make "Do It Yourself" style videos, perhaps of lesser quality in terms of production values yet potentially equal, if not more valid, in terms of being purposefully designed to support specific learning outcomes for specific students. Not surprisingly, this idea caught the interest of many music teachers and education providers because, regardless of changing formats, mode of distribution or level of production, the primary purpose of music teaching and learning resources is always to provide an informative and reliable point of reference to guide students as they practice. This contention is evident in past and present publications that are designed to help students become self-directed in their approach to practice and learning (Chaffin, 2011; Powell, 1984; St George, 1990; Turner, 2013).

In short, turn of the millennium advances in a range of digital video capture, editing and streaming technologies coincided with the rollout of newer, faster and higher quality videoconference solutions (both computer desktop-based and larger room-based systems). Together, with rapid global expansion of the Internet, these advances in video and videoconference technology seemed set to revolutionise music teaching and learning, if not education in general.

Literature review

Based on the assumption that significant developments in music education are generally reported in scholarly publications, this article presents a review of selected music education and education technology research publications with a particular focus on videoconference and

video-assisted instrumental music teaching and performance in higher and further education settings reported in Australian studies. Past and present articles were compared to find evidence of recent developments in digital video and videoconference-mediated music teaching and to determine whether the implications of earlier studies have been realised. The contents of the articles were analysed with a view to determining how videoconference-mediated music teaching strategies are being integrated in higher and further education settings in Australia. Answers to this guiding research question were sought by adopting a two-phase methodology, comprised firstly of a literature review, followed by a thematic analysis of the content of the papers and articles identified. In order to provide evidence-based answers to the aforementioned research question, a collection of recently published, peer-reviewed sources of literature were identified and analysed for the purposes of synthesising information extracted from these sources.

Inclusion and exclusion criteria were used to establish the boundaries of the literature review, as outlined in Table 1. While the inclusion criteria were used to define which sources were to be included in the review, they also defined the processes used to conduct the review. The exclusion criteria were especially helpful in defining sources of literature that were disqualified for inclusion in the review (Boland, Cherry, & Dickson, 2017).

Once the sources of literature were identified to include in the literature review, the text from each of the articles was thematically analysed. Specifically, the qualitative comparative analysis method (Glaser & Strauss, 1967; Maykut & Morehouse, 1994) was used to guide the identification of themes evident in the text of the articles. Throughout the analysis process, the research question acted as the overall guiding principle to target the extraction of information from the literature sources selected for inclusion in the review.

Scholarly databases accessed through online university library sites including ProQuest,

Table 1: Inclusion and exclusion criteria for literature review.

	Inclusion criteria	Exclusion criteria
Date range	From 1998-2016	–
Type	Peer reviewed journal articles and conference papers, due to their currency	Books, websites*
Context	Australia, school, TAFE, university, higher education, tertiary education	Kindergarten, pre-primary education, international references were originally excluded but included in the final stage of the review
Key search topics	videoconference-assisted; instrumental; music teaching	Theoretical music education, history of music
Key search terms	videoconference, music, education, video, teaching, learning, Australia; ICT-assisted music teaching and learning; asynchronous video-assisted teaching and learning; training	Instrumental music teaching
Methodological approaches	Qualitative, quantitative, mixed methods	–
Sources	Library databases searched include: ProQuest, EBSCOhost, SAGE and Cambridge	–

** The initial intention was to use only peer reviewed journal articles reporting on Australian studies of direct relevance to the research questions. Few articles matched this criterion exactly, therefore, subsequent searches were expanded to include conference papers. Books were not included because they take longer to get published and are, therefore, not always as up-to-date in terms of technology-related issues and websites are not always peer-reviewed. Some websites were accessed in the course of following up on themes or issues raised in selected articles and papers but systematic web searches were not included in the core method and design.*

EBSCOhost, SAGE and Cambridge were searched to locate relevant literature. In accord with the aim and scope of the study, priority was placed on locating studies of videoconference-assisted instrumental music teaching within Australia around the 2000s through to the present day. Very specifically defined keyword searches for 'instrumental music teaching by videoconference in Australia' returned few results. Subsequently, broader searches were conducted with words such as 'instrumental' omitted from the term 'instrumental music teaching', whilst the keywords (such as videoconference, music, education, video, teaching, learning and Australia) were retained. One of these broader searches resulted in thirty-eight titles that were of some relevance to the broader topic of ICT-assisted music teaching and learning (especially school and TAFE education and training) and, to a lesser degree, asynchronous video-assisted teaching and learning. Few studies, however, mentioned synchronous videoconference-assisted music teaching much less the results of systematic research into synchronous videoconference-assisted 'instrumental' music teaching.

A small number of particularly relevant refereed journal articles and refereed conference papers (7) were located. These articles reported the findings of various Australian studies and videoconference-mediated instrumental music teaching and performance initiatives, spanning a period of several decades (1998-2016). These articles were located in the *Australian Journal for Music Education*, the *Australasian Journal of Educational Technology*, the *International Journal of Instructional Technology* and *Distance Learning* and conference proceedings of the Australasian Society for Computers in Learning in Tertiary Education (ASCILITE) and the Australian Council for Computers in Education (ACCE). Other more general education technology projects that included some reference to videoconference or video-assisted teaching of music in Australia were found in the *Journal of Distance Learning*, *Higher Education Research & Development, HERD* (the journal of Higher Education Research and Development Society of Australia (HERDSA)) as well as the *Australian Journal for Music Education*. Whilst initial literature searches were tightly focused on locating studies concerning video and videoconference mediated music teaching in Australia, the need to explore some issues in more depth and in relation to international practice and perspectives emerged during preliminary data coding. Although the articles and papers identified through the application of the original inclusion and exclusion criteria did not include international sources of literature, it became evident through the coding of the text in the included articles that some relevant issues to the main topics of the literature review were cited in international sources. Consequently, a number of international research articles were sourced in the course of examining references and issues cited in Australian research articles which remained the primary sources for analysis.

Qualitative analysis

A qualitative comparative analysis method, such as described by Glaser and Strauss (1967) and Maykut and Morehouse (1994), guided the approach to coding and categorisation of qualitative data. Aided by the search, compare and coding functionality of NVivo™ qualitative analysis software (QSR International, 2016), predetermined topic nodes were used to provide an overall structure to the thematic analysis and emergent sub-nodes (child nodes) were developed to reflect categories of data observed in the full-text articles. In this way, the qualitative analysis of the data incorporated a combination of both inductive and deductive coding processes (Patton, 2015). This approach ensured that the original search terms of the literature review and the content of the literature identified in the review were reflected in the findings of the qualitative analysis.

Predetermined topic nodes were given broad (though provisional) descriptive labels such as: music teaching (by videoconference); music performance (by videoconference); instructional

video-assisted music teaching; ICT-assisted teaching, and ICT infrastructure. Further nodes and sub-nodes (child nodes) emerged through the more inductive process of selecting "individual units of meaning", that is, sentences, phrases or keywords that could be understood with little information besides the focus of the study (Maykut & Morehouse, 1994, p. 135). Some of these nodes included: technical challenges and developments (including 'unavoidable impediments' and 'avoidable impediments'); pedagogical challenges and developments (including 'strategies to overcome challenges'); affordances; repetition of past studies, and sustainability and effectiveness of online education. The "drag-and-drop coding" function of NVivo was used to create these new nodes based on the selected text (QSR International, 2016, p. 5). As the coding process progressed, similarities between some nodes and sub-nodes were identified and, in such cases, these were either combined or the sub-codes were collapsed into higher nodes.

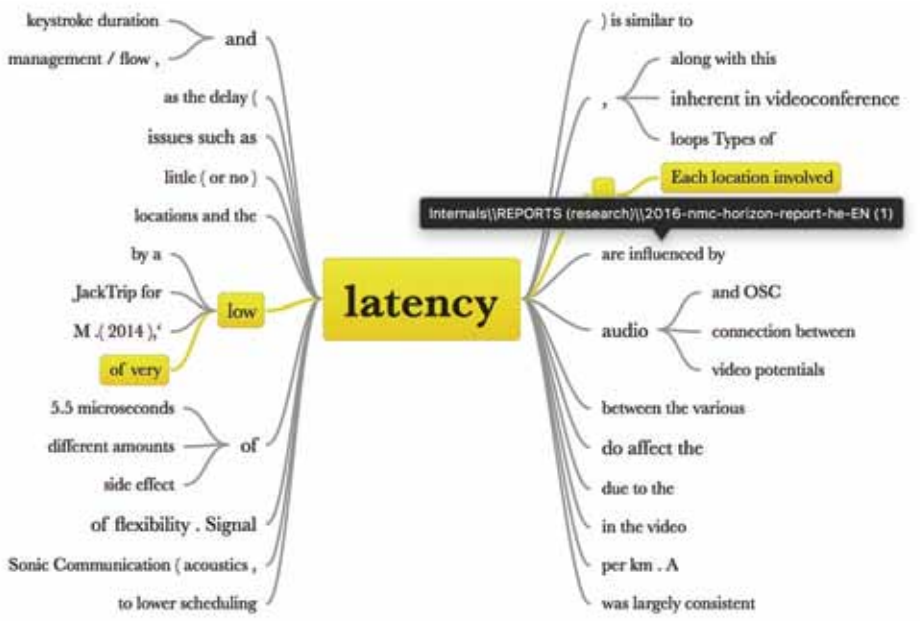
Coding and testing of emergent nodes and propositional statements

As the aforementioned process continued, each node was examined in the light of new data and either incorporated into existing nodes or new nodes were created where necessary as dictated by the new data. The 'explore' and 'query' functionality of NVivo was used to develop, test and refine hunches and propositional (provisional) statements, for example, that:

> … during a videoconference, delay (latency) can be problematic for remote site participants trying to play along in sync with teachers at the host site.

As a first step to locating confirming or disconfirming evidence for this propositional statement, a text search for the word 'latency' was

Figure 1: Word Tree representation of Text Search results for the term 'latency.'



initiated across all sources. The following image (Figure 1) shows how the term 'latency' was found and its context explored in a word tree.

Examining results

Results displayed in 'summary' form likewise revealed multiple matches for the term latency. These matches were found across four out of six primary source articles with a specific focus on video and videoconference-assisted music teaching, and six of nine across articles on ICT-assisted education that included some general reference to synchronous communications technology. On closer examination of the original sources, clear statements noting the problematic effects of latency for synchronising live music performance and teaching activities were found in two recent studies as well as studies dating back to the early 2000s. One of the recent studies notes, for example, that challenges from a music performance perspective come down to "sonic communication (acoustics, latency, loops)" whilst the fibre optic cables that enable "packets of data to be sent around the world at the speed of light result in 5.0 to 5.5 microseconds of latency per km, which equates to an approximately 2 second delay at the time of the STCC study" (Redhead, Scott, & Vella, 2012, p. 3). Similarly, a 2015 study notes that "when teachers were asked to "clap in time with the music a slight lag in the timing of images from each location meant they were not visually, 'in time'" (Dezuanni, Arthurs, & Graham, 2015, p. 39). Earlier studies, located in text search results for 'latency', had arrived at similar conclusions about the implications of 'latency' for videoconference-mediated instrumental music teaching (Anderson, 2008; Anderson & Fitzgerald, 2007; Anderson cited in H. Riley, MacLeod, & Libera, 2016). In contrast, a false-positive search result for the term latency was found where the word was used in a context unrelated to music teaching or videoconference and video-assisted music teaching (Johnson et al., 2016).

Through further exploration of pre-determined and emergent node structures and sources, a list of propositional statements emerged and were tested, refined or discarded as indicated in Table 2.

Summary and discussion

A number of significant technology-infrastructure developments foreshadowed in turn-of-the-millennium ICT and music education literature have been realised. For example, more powerful computers, faster broadband networks, larger and more flexible storage and streaming options (Johnson et al., 2016; The New Media Consortium, 2004). In Australia, faster broadband services have been rolled out, enabling improved Internet access for schools, technical colleges and universities. The coverage of such networks is not spread evenly across the continent nor individual states and territories, however, satellite technology is helping to bridge gaps across terrestrial networks (Australian Communications and Media Authority, 2015).

The Interactive Distance Learning Satellite Project (IDL), for example, involves partnerships between Optus, NSW Department of Education and Training, Northern Territory Department of Education, local communities and schools. Known as the Satellite Education Program (SEP) within New South Wales schools and Interactive Distance Learning (IDL) for TAFE NSW and Northern Territory schools, the satellite supported system provides two-way broadband voice, Internet and one-way video to support interactive lessons (including music) and vocational education courses for rural and remote Aboriginal and non-Aboriginal communities (Crump et al., 2005; Sedgers, Johnson, Smyth, & Waite, 2005). A subsequent research project funded by Australian Research Council investigated user experiences of the system between 2007 and 2009 and reported positive outcomes including high levels of user satisfaction among teachers, students and their families (Crump et al., 2009).

As foreshadowed by Beveridge (2010) and later confirmed by Dezuanni et al. (2015), by 2012 every New South Wales government school was provided with an interactive classroom featuring video

Table 2: *Propositional statements emerging from exploration of predetermined nodes and emergent sub-nodes.*

Predetermined topic nodes and emergent sub-nodes based on 'units of meaning'	**Propositional statements emerging from comparative analysis across emergent nodes and sources**	**Refined statements**	**Related literature**
Predetermined topic nodes: ICT-assisted teaching; ICT infrastructure. Emergent sub-nodes: technical and pedagogical challenges, developments and affordances.	ICT-infrastructure developments in turn-of-the-millennium literature have been realised. Broadband services rolled out but coverage not evenly spread. Satellite technology can bridge gaps across terrestrial networks.	As foreshadowed in turn-of-the-millennium literature, more powerful broadband computer networks, storage and streaming options, are now better able to support asynchronous video and synchronous videoconference-mediated music teaching. Satellite services are helping to broaden network coverage and improve connectivity between metropolitan and remote areas of Australia.	Maki (2001); Anderson and Ellis (2001, 2005); The New Media Consortium (2004); Johnson et al. (2016); Crump et al. (2005); Beveridge (2010); Australian Communications and Media Authority (2015); Dezuanni et al. (2015)
Predetermined topic nodes: ICT-assisted teaching; ICT infrastructure. Sub-nodes: technical challenges, developments and affordances.	Delay (due to latency) still adversely affects the quality and synchronisation of image and sound during a videoconference.	Synchronising multi-site instrumental music performances, especially duets remains problematic due to latency.	Anderson, cited in H. Riley et al. (2016); P. E. Riley (2009); Redhead et al. (2012); Anderson, cited in H. Riley et al. (2016)
Topic nodes: Music teaching and performance by videoconference. Sub-nodes: technical challenges, developments and strategies, affordances (feasibility)	Latency can be countered to a degree by using a combination of low latency audio technology and OSC for music data transmission, in conjunction with a suitable high-definition videoconference system.	Low latency audio and OSC for music data transmission can help offset the effects of latency during a videoconference and is a promising development.	Redhead et al. (2012); H. Riley et al. (2016)
Predetermined topic nodes: ICT-assisted teaching; ICT infrastructure. Sub-nodes: technical challenges; affordances.	The benefits of videoconference mediated music teaching and outreach outweigh the challenges	A recurrent theme in Australian studies of video and videoconference-mediated music teaching is that participating music teachers have acknowledged there are benefits of using videoconference technology for distance and cross-institutional music teaching, outreach and professional development, especially where meeting face to face is not practical or economically viable. Further, the perceived benefits were seen as outweighing the technical challenges and constraints.	Gordon et al. (2000); Anderson and Ellis (2001, 2005); Anderson and Fitzgerald (2007); Devlin, Feraud and Anderson (2008); Dezuanni et al. (2015); Redhead et al. (2012)

Predetermined topic nodes and emergent sub-nodes based on 'units of meaning'	Propositional statements emerging from comparative analysis across emergent nodes and sources	Refined statements	Related literature
Topic nodes: Music teaching by videoconference. Sub-nodes: avoidable impediments; technical challenges.	Not all reported impediments to clear videoconferencing are linked to shortcomings of the technology.	Many recurrently reported problems with communication by videoconference can be avoided or offset with sufficient know-how, preparation and set up time for teachers, support staff and students.	Gordon et al. (2000); Anderson and Ellis (2001, 2005); Anderson and Fitzgerald (2007); Dezuanni et al. (2015); Redhead et al. (2012)
Topic nodes: ICT infrastructure, music teaching and performance by videoconference. Sub-nodes: avoidable impediments.	Rooms not optimised for performing or teaching and learning music by videoconference can hamper clarity of communication.	Lack of physical space, poor acoustics, inadequate lighting and positioning of furniture and equipment can be problematic, especially in venues not optimised for performing or teaching music by videoconference.	Anderson and Fitzgerald (2007); Dezuanni et al. (2015); Redhead et al. (2012)
Topic nodes: ICT music teaching and performance by videoconference. Sub-nodes: avoidable impediments; strategies; affordances.	Teachers could take a more active role in setting up for videoconference mediated teaching and performance.	Given sufficient training and technical support, teachers and students can learn to do adequate equipment, image and sound checks (pre-lesson) so as to optimise their video and videoconference-assisted music teaching and learning experiences.	Gordon et al. (2000); Anderson and Ellis (2001, 2005); Anderson and Fitzgerald (2007); Dezuanni et al. (2015); Crump et al. (2009)
Topic nodes: Music teaching by videoconference. Sub-nodes: avoidable impediments; strategies.	Technical and pedagogical strategies documented during earlier studies may still apply.	Many previously documented strategies for instrumental music teaching by videoconference are still relevant, for example, teacher and student take turns to hear each other play solo or to pre-recorded backing tracks and videos distributed ahead of a synchronous lesson.	Anderson and Ellis (2001, 2005); Anderson and Fitzgerald (2007)
Topic nodes: Music teaching Sub-nodes: Asynchronous video music teaching	Asynchronous video-assisted learning can facilitate authentic learning experiences	Digital video resources can give students a window into cultural music making practices that lay beyond their own culture and personal experience.	Klopper (2010); Kearney and Schuck (2006); Power and Bradley (2011)

conferencing facilities, an "interactive whiteboard … and data collaboration software" (p. 40). These classrooms form links in the chain of the Department of Education's 'Connected Classroom' system which enables live synchronous interaction between teachers and students across multiple geographically dispersed sites.

Outside organisations and non-DEC schools can connect to the Connected Classrooms system facilitated by 'Connections', a project of the New South Wales Department of Education and Communities (NSW DEC) unit, Distance And Rural Technologies (Department of Education and Training Distance and Rural Technologies, 2018). The Sydney Opera House, for example, connects with its own multimedia and audio production facility that the Sydney Symphony Orchestra (SSO) has used to produce and present multimedia-rich presentations and facilitate Professional Development (PD) activities for generalist classroom teachers (Dezuanni et al., 2015). Dezuanni et al. (2015) reported on one such initiative using data collected as part of a "three-year Australian Research Council Linkage project, Remote Musical Interactions". Notable in this study is a balanced examination of constraints as well as affordances of the technology, as experienced by the SSO facilitators, participating teachers, technicians and education officers involved. Constraints, for example, were evident when teachers were asked to "clap in time with the music a slight lag in the timing of images from each location meant they were not visually, 'in time'" (p.39). The study concluded the benefits of linking to these remote sites outweighed the challenges of conducting a PD workshop in this manner, however, more research would be necessary to determine whether this one-off event was "truly transformative", in terms of a positive impact on the participating teachers' confidence to teach music in the classroom (ibid.).

While it is not appropriate to generalise based on an isolated event, it is significant to note similar and recurrent observations across multiple studies over a longer period. For example, the fact that latency can be problematic for remote site participants trying to play along with facilitators at the host site or hub of a hub-and-spoke configuration, has been noted recurrently over several decades of research into using videoconferencing for teaching music (Anderson & Ellis, 2001, 2005; Crump et al., 2009; Gordon et al., 2000).

Redhead et al. (2012) report on such challenges encountered during collaborative cross-institutional music performances by videoconference. Promising, however, in terms of new technical developments and strategies, is that the perception of delay (due to latency) was countered to a degree by using a combination of open source technology such as "'JackTrip' for low latency audio and OSC for music data transmission" in conjunction with a commercially available Polycom videoconferencing system. This collaboration between the Newcastle Conservatorium of Music in Australia and five overseas institutions, enabled researchers and participants in the International Space Time Concerto Competition (ISTCC) "to explore networked music performance (NMP) and its utilisation in the concerto form". The main challenges, from a music performance perspective, were noted as:

- visual communication (sight lines);
- sonic communication (acoustics, latency, loops);
- types of musical interactions and textures; and
- integration of performing spaces" (Redhead et al., 2012, p. 1).

Similar challenges identified in earlier studies include the use of rooms that are not optimised for performing or teaching and learning music by videoconference. Lack of physical space, poor acoustics or inadequate lighting can be problematic in such venues. The layout and position of furniture and fixed-installation videoconference equipment may also limit the usability of a room for music teaching and performance. Anderson and Fitzgerald (2007) found that videoconference rooms set up in a typical boardroom configuration

were restrictive for instrumental music teaching and time was needed for rearranging furniture as well as positioning cameras, audio equipment and the musical instruments.

Further, in regard to the merit of purpose-built venues, Dezuanni et al. (2015) note the Opera House function room used to host a music PD workshop for school teachers "was not set up to be a genuine broadcasting space with appropriate acoustics and lighting, and this compromised the quality of the [videoconference-mediated] 'broadcast" (p. 39). Specifically, the quality of the video fluctuated and made visual cues including facial expressions difficult to decipher. In addition, audio glitches due to network issues reduced the clarity of communication.

Similar issues were identified in relation to the Space Time Concerto Competition (ISTCC) reported by Redhead et al. (2012) which, in contrast, did take place in purpose-built music performance venues equipped with broadcast quality audio equipment. Evidently network constraints, and latency in particular, remain the most challenging obstacle in the way of achieving consistently fluid and high-resolution sound and vision during a synchronous videoconference (whether it be by a high definition commercial system, lower cost desktop computer or mobile device-based videoconferencing solutions).

Not all factors that interfere with the clarity of communication are inescapably linked to physics or shortcomings of the technology being used. For instance, cameras that are poorly positioned and inadequately focused may result in an incomplete or unclear view of the action. In other cases, unwanted audio feedback and distortion caused by incorrect audio settings or poor positioning of monitors and microphones may be an issue. Whilst avoidable to some extent, such occurrences have been recurrently documented in successive studies of videoconference-mediated music teaching and performance initiatives (Anderson & Ellis, 2001; Anderson & Fitzgerald, 2007; Dezuanni et al., 2015; Gordon et al., 2000). This bids the question: *What can be done to make the most of lessons learned to date and improve outcomes for future practice and research into videoconference-mediated music teaching and learning?*

Given sufficient technical support and training, teachers can do vision and sound checks, making basic control setting adjustments and repositioning equipment where applicable. This is evident in the previously cited studies of SEP and IDL user experiences whereby teachers in distance education schools and TAFE colleges routinely use such technology. The importance of pre-testing different network signal paths ahead of cross-institutional, interactive music performances is also important and notably emphasised in the previously mentioned ISTCC study (Redhead et al., 2012). Responsibility for complex videoconference network testing often lays rightly with specialist Audio-Visual (AV) and Information Technology staff, however, a number of studies indicate that optimal vision and sound may be achieved more readily given sufficient time and resources for staff and students to set up and use videoconference technology in sufficiently flexible teaching and learning spaces.

A number of higher education researchers have focused their work around developing and testing new models of teaching/learning (Englund, Olofsson, & Price, 2017; Price & Kirkwood, 2014) given the affordances of ICT for synchronous and asynchronous communication (Cole & Throssell, 2008; Kim, Park, Yoon, & Jo, 2016; Roberts, 2009). While past research has identified learning advantages to both forms of online communication, the affordances of each type of communication lend themselves to the field of music education. Indeed, it would seem short-sighted to conceive of a new model for synchronous videoconference-mediated instrumental music teaching without giving due consideration to how instructional videos for asynchronous learning might be integrated in practical/technical terms and from an instructional design point of view.

Early asynchronous video-assisted learning

initiatives shared many similar technical constraints as synchronous videoconferencing. Work around strategies for music teachers included the practice of sending larger instructional videos and lesson content files on CD-ROM or DVD by post ahead of a lesson by videoconference. Meanwhile sufficiently compressed and smaller file-size instructional videos could be sent by FTP, email or made available for download from a web site or Learning Management System (LMS) such as Moodle or Blackboard (Anderson & Ellis, 2001, 2005). During a videoconference lesson, the teacher and student(s) could take turns to hear each other play solo or play along with pre-recorded backing tracks distributed ahead of a synchronous lesson (ibid). Such strategies still have relevance today because despite obvious improvements in the speed and capacity of broadband infrastructure, it still makes sense to keep file sizes to a minimum for faster download.

A further example of asynchronous music teaching and learning enhanced by the integration of digital video technology is evident in Klopper's (2010) account of an exchange that took place between students of North-West University (NWU) in South Africa and Charles Sturt University (CSU) in Australia using a combination of video, online-chat room and web-cam communication. The NW students "prepared musical artefacts for 'export' to Charles Sturt University" and these "conveyed, confirmed and explored their culture of birth." CSU students were asked to "create a performance of the musical artefact using Orff melodic and non-melodic instruments" (p. 48). Klopper notes "the technology did not support synchronous intercultural music making" … though it "did support asynchronous engagement" that in turn facilitated "intercultural music-making performances" (2010, p. 6).

Conclusions

Reports of high-definition videoconferencing systems being used to support the teaching of creative and performing arts (including music) in Australian schools and TAFE are well-represented in the Australian research literature reviewed in this article. Several Australian and overseas studies indicate that some progress has been made towards counteracting the effects of latency which hampers synchronisation between local and remote site participants during videoconference-mediated music teaching and performance activities. Even the more recent of these research articles, however, show that activities such as playing a duet on acoustic instruments in perfect synchronisation across multiple videoconference sites are still not practical due to latency. It should be noted that, in contrast, interactive performances over the internet using Musical Instrument Digital Interface (MIDI) compatible instruments is feasible because such instruments and controllers simply transmit digital data conveying instructions for playback on a MIDI instrument or module and speakers located at the remote site or sites. Capturing, transmitting and synchronising actual sound emanating from acoustic instruments or electric instruments played back through amplifier speakers is an entirely different technical challenge to overcome, as evidenced by the studies cited in this article.

The present study found more similarities than expected between recent and past studies. For example, an analysis of these studies showed that students and staff facilitating videoconference mediated music lessons need ready access to technical support, purpose-built or customisable facilities, and sufficient time for lesson planning, set-up and operation of equipment and software. Reports of high definition videoconferencing being used routinely in the context of Australian university music programs were less common than expected and runs somewhat contrary to predictions made in some pre-2000 studies. Whateley and Russell (1997), for example, predicted that university music schools may in future make greater use of satellite sessional staff who could use technologies such as video conferencing to teach students across multiple sites. Use of digital video for online music

teaching and sharing of recorded performances, on the other hand, has mushroomed in schools and tertiary education, largely as predicted in some earlier turn-of-the-millennium studies. In one of the author's professional experience, synchronous web conferencing applications such as Adobe Connect, Skype are used periodically in various higher and further education music programs but the present search of Australian studies revealed no studies specifically devoted to the use of these tools in this context much less instrumental teaching in particular.

Room-based and desktop videoconference technologies are sometimes used to include remote site venues in large-scale, multi-campus music lectures and seminars. Meanwhile many instrumental teaching method books and the like still advocate small group or one on one tuition where possible. Such student-to-teacher ratios are considered by some to be out of step with the demands on modern higher education. In fact, scholars such as Madsen and Madsen (1969, p. 6) were making this assertion in the late 1960s. The answer for modern music programs that include instrumental music tuition and performance must surely lay in continuing to streamline the integration of synchronous and asynchronous video and videoconference technologies in ways that account for the different requirements of instrumental music teaching and performance activity versus music subjects that can be taught more readily on mass to large cohorts. In either context, keeping abreast of valued practice strategies and further refining them, from basic set up and positioning of instruments and cameras for videoconference or pre-recording a lecture through to comprehensive mapping and revamping the instructional design of entire music programs, will surely help to continue improving the student and staff experience of online and videoconference mediated music teaching and learning.

The present review of past and recent studies of videoconferencing and video for synchronous and asynchronous music teaching has implications for on-campus and online education in schools and tertiary colleges. Clearly, digital video resources are having a positive impact on blended and online modes of music education, almost exactly as foreshadowed by some Australian researchers and their overseas counterparts, almost two decades ago. While videoconferencing still has some technical limitations that are being countered to a degree with the emergence of new and complementary technologies, perhaps most important in the short term, is to heed what previous studies have established in terms of best practice for using these technologies.

In summary, the following specific recommendations have been extracted from this review of a specified set of research articles and papers outlined in this article and their subsequent analysis:

- **Hardware should not be overlooked.** The quality of communication via videoconference or pre-recorded instructional video can be maximised by attending to practical issues, already reported at length in previous research, such as the appropriate positioning of microphones, cameras and lighting.
- **Flexibility needed in respect to venues, furniture and hardware.** Hardware issues are just as important as software issues. Software programs rely on and are supplemented by hardware such as cameras, lighting and microphones. Given that such equipment and furniture will inevitably need repositioning at times to optimise sound and vision for various types of instruments and performances, teachers need the authority and know-how to re-position things as required. Alternatively, specialist technical support staff should available to assist as required.
- **ICT support and training.** Music teachers and music course designers cannot be expected to be fully skilled in all of the ICT-related aspects associated with the use of synchronous and asynchronous online communication tools. To

supplement their skills, however, institutions are recommended to:

  - allocate ICT-skilled staff some time to assist teachers using such technologies;
  - allow teachers access and time to set up and test-run audio-video equipment with "technology help" close at hand; and
  - provide teachers with low level technology training that is sufficient to enable them to quickly troubleshoot minor technical problems.

- **Consideration of file size and file sharing.** To work around the problems associated with the non-synchronicity of current so-called synchronous technology, the use of file compression software and the practice of sharing large video files in advance of synchronous video conference-mediated teaching and performance activities remains a relevant strategy.
- **Successful use of multiple online tools.** In situations in which optimum quality audio-visual resolution and synchronisation is less essential to the success of a particular music lesson or performance activity, the integration of other online tools such as chat, webcams, online messaging or MIDI (Musical Instrument Digital Interface) supported online jamming applications may be used in conjunction with (or instead where applicable) high definition commercial videoconference systems. Primarily, music educators need to remain cognizant of the strengths and limitations of these different technologies and plan accordingly taking known technical and pedagogical strategies into account.
- **Improve on previously developed strategies.** When planning to use videoconferencing technology, music teachers and designers of music courses are encouraged to take heed of 'lessons learned' from previous researchers and educators, such as the authors of the articles selected for review and outlined in this article. Then further refine or develop new strategies for sharing with others.

These recommendations are offered here for consideration by those engaged in the business of designing and teaching music education courses in on-campus or online contexts in the context of schools and tertiary colleges. Application of these recommendations may offer future opportunities for continued research in this area such as investigation into appropriate portions of asynchronous video-assisted learning and videoconference-mediated teaching, learning and performance activities for distance and on-campus learning.

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Dr Alan Anderson *is a lecturer in music at the University of New England in New South Wales Australia. Alan's early research in music education examined the role and importance of peripatetic instrumental music teachers for regional communities. More recently, Alan has worked with a number of cross-institutional research teams on distance e-learning projects involving TAFE colleges, Universities and the School of The Air in rural and remote areas of Australia.*

Maria Northcote *is an Associate Professor in the Faculty of Education, Business and Science at Avondale College of Higher Education in New South Wales Australia. She is an experienced higher education teacher, leader and researcher and is involved in undergraduate and postgraduate education, and professional development.*