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Evaluating the use of LoLa in European conservatoires: The SWING project

ABSTRACT

The research presented in this article reports on the SWING project, a qualitative case study initiated by The Association Européenne des Conservatoires, Académies de Musique et Musikhochschulen (AEC) into the use of LoLa (low-latency audio-visual streaming) for instrumental music teaching between conservatoires. LoLa is a software package that allows musicians to perform and interact together synchronously in real-time with high-quality audio, something not currently possible with standard videoconferencing platforms. LoLa is a relatively new technology and there is limited research available on how effective it is when used for instrumental music teaching. Trials of LoLa technology were conducted in three conservatoires in Austria, Italy and Slovenia in early 2019. Follow-up interviews were conducted with music teachers, students and technicians to understand their experiences of using the technology, what changes took place in the teaching, and to determine the potential and limitations of LoLa for teaching in conservatoires. Participants in the trials reported overall satisfaction with the system, with many being surprised at the high quality. The findings showed that LoLa can expand the possibilities for artistic development by facilitating synchronous interaction between teachers and students in different conservatoires. These possibilities include one-to-one lessons, group masterclasses, examinations, and opportunities to rehearse and perform synchronously with musicians from other institutions. This aligns with current research which calls for a reappraisal of the traditional one-to-one conservatoire studio lesson.

KEYWORDS

LoLa
low-latency
videoconferencing
vocal and instrumental music teaching
conservatoire
online learning
music education
music pedagogy

INTRODUCTION

LoLa (low-latency audio visual streaming) is a software package that allows musicians to interact synchronously in real time in a way that has not previously been possible. Teachers and students can interact with each other remotely from different locations at a distance of up to 3,500 km (Drioli et al. 2013), greatly expanding the possibilities for teaching, rehearsing and performing. LoLa is a relatively new technology and there is limited research available on how effective it is when used for instrumental music teaching (Davies 2015; Redman 2020; Riley et al. 2016).

The Association Européenne des Conservatoires, Académies de Musique et Musikhochschulen (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 a European Union programme to support students to study and train abroad (European Commission n.d.). The aims of the SWING project are to experiment with and establish transnational learning opportunities through deploying technologies such as LoLa to accelerate collaboration among institutions by supplementing physical movement with a virtual presence (AEC n.d.).

Trials of LoLa were conducted in three conservatoires in Austria, Italy and Slovenia in early 2019. Following the trials, interviews were conducted later in 2019 by three different researchers with trial participants including teachers, students and technicians. The project aligned with my own doctoral research goals and I assisted the project team in developing the interview prompts. Questions guiding my research include:

- What changes in the quality of the experience in studio lessons between face-to-face and low-latency settings?
- How do different elements of music instruction change from face-to-face to low-latency settings, and are some elements more or less effective in these different environments?
- What are the barriers to using low-latency technologies in educational settings, and how can these be overcome?

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 twenty-first-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. Some of these approaches will be discussed in relation to LoLa settings:

- collaborative learning, with increased access to a wider international pool of teachers and fellow students;
- changing dynamics in the power relations between teachers and students;
- students becoming more autonomous and self-directed, and less dependent on their principal teacher.

CONTEXT

Studio lessons in the conservatoire

Studio lessons, based on the one-to-one or master–apprentice model, are a foundational part of conservatoire music education (Burwell 2013; Carey et al. 2013; Gaunt 2008). The apprenticeship model has a long tradition in instrumental music education and is found in many different musical cultures (Gaunt et al. 2021). Burwell writes that the model is a 'richly-textured and complex practice' (2013: 276) 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 (Burwell 2013).

There are many benefits and advantages of the master–apprentice model, including allowing for a highly personalized 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: 378). Students often admire and respect expert teachers, and value their authority (Maidlow 1998).

Zeltsman (2003) describes different approaches to specialist instrumental music study. Learning intensively for several years with one specialist teacher has a 'purity' of approach which can keep a student focused. It also requires 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 specialization. However, it can sometimes be difficult to reconcile different approaches to specialist study, which may lead to students becoming confused and disheartened. Ultimately, when faced with sometimes conflicting information and opinions, students have to make their own judgements as to which approach is best (Zeltsman 2003).

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 that may disadvantage the student (Duffy 2016: 378). Students may also play 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). 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 how 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).

Recent developments

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 twenty-first-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: 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 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' (2013: 1). These include cooperating beyond geographical boundaries, meeting new social situations and navigating cultural difference (Gaunt and Westerlund 2013). 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 social dimensions of learning through communities of practice, that help develop expertise through a wider horizon of learning possibilities.

Zhukov and Sætre describe a 'teaching-through-playing' (2021: 1) 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 (2021: 4). However, they also note that it is important to match the skill levels of participants in group learning, something that may be a challenge in a small conservatoire setting.

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: 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 teaching and learning 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 recognized by the establishment in 2006 of the Innovative Conservatoire (ICON) to scrutinize and develop established pedagogies (Duffy 2016).

Videoconferencing

The use of videoconferencing has been shown to successfully facilitate instrumental music lessons between teachers and students in remote locations (King et al. 2019; Prior et al. 2015; Shoemaker and van Stam 2010). The many 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 (Dammers 2009; Koutsoupidou 2014; Kruse et al. 2013; Prior et al. 2015; Shoemaker and van Stam 2010). A more recent study carried out by King et al. (2019) examined teacher and pupil behaviours in online lessons in rural areas of England delivered via the Skype videoconferencing platform. The findings showed that there were challenges regarding audio and video quality, as well as problems with internet connections.

LoLa

In response to the demand from musicians for more effective audio-visual streaming systems, LoLa (low-latency audio-visual streaming) was conceived at the Conservatorio di Musica Giuseppe Tartini of Trieste in 2005, and developed between 2008 and 2010 with the collaboration of GARR, the consortium that runs the ultra-broadband network dedicated to the Italian research and education community.

LoLa is a software package that runs over a specialized 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 1300 km apart (Drioli et al. 2013).

There is limited research available on how effective LoLa technology is when used for instrumental music teaching and the available literature suggests a need for more in-depth testing (Davies 2015; Redman 2020; Riley et al. 2016). The research presented in this article attempts to assess the suitability and potential of LoLa for transforming instrumental music teaching in conservatoire settings.

METHODS

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 short series of lessons of up to one hour each in duration. The 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.

Following the trials, initial surveys were conducted with participants, followed by semi-structured guided interviews. 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. I assisted the project team in developing interview prompts related to:

- the pedagogical advantages and disadvantages of LoLa;
- the participants' own personal relationship with technology;
- how 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 with individual participants either face-to-face, or by videoconferencing, by three different researchers from the AEC. The interviews in Slovenia were conducted in English; the interviews in Italy and Austria were conducted in their respective languages. Interview transcripts were translated into English in preparation for analysis.

Broad 'a priori' themes were identified from the research questions, but inductive coding was used to allow new themes to arise from the data (King 2016). Codes were assigned to different parts of the text which were then added to a hierarchical coding frame, grouped together into themes and summarized. 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.

Ethics

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. Prior to the interviews, verbal consent was gained from each participant for the anonymized data to be used as part of the SWING project and any related third-party projects.

Validity

Validity was addressed by being aware of possible biases including reactivity, respondent bias and researcher bias (Lincoln and Guba 1985). By being separate from the interview process, I was able to maintain a degree of objectivity and thus eliminate the possibility of reactivity with the interview subjects. There was the potential for respondent bias, but the interview prompts asked participants for their individual and subjective responses to the use of technology. As such, there were not 'true or false' questions, so respondent bias was not considered a significant factor.

In coding and analysing the data, I looked at the interview transcripts through the lens of my own theoretical framework. I was assessing the suitability and potential of LoLa for instrumental music teaching in conservatoire settings, and also bringing my dual professional knowledge both as an experienced music educator and as a researcher in the field. Thus, there was the potential for researcher bias; however, the coding was inductive, and a summary of what was actually said, which helped to control researcher prior assumptions.

Robson (2002) suggests other strategies to further remove threats to validity of the data including triangulation, prolonged involvement, and keeping an audit trail. Data sets 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 for reference.

FINDINGS

The rationale for using LoLa

The main advantage of LoLa over other audio-visual streaming platforms, including Polycom and UltraGrid, is the extremely low latency, thus facilitating synchronous musical interaction between participants in remote locations. Teachers, students and technicians commented: 'the great thing about LoLa is this lack of latency', and 'the delay wasn't a problem, it worked really well'.

One of the LoLa developers 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 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. An 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 they also felt that face-to-face rehearsals were important:

> 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 before trying LoLa, they would have said 'no', but having tried LoLa, they felt it may now be possible. Students commented on the experience of taking an exam via LoLa as being potentially more comfortable than face-to-face:

> 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'.

Lessons via LoLa could be an advantage with regards to the quality of studio environment and instruments used by teachers physically visiting different institutions. 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, acoustic and quality conditions for the instruments available here […] than there'.

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.

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.

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 decide on suitable countries, cities and teachers 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 meet 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'.

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 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 from different angles, a point echoed by a technician who recognized that the participants were not 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 programmer 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 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 and unadulterated. […] 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.

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.

An 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:

> Especially at the beginning 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'.

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 also 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'.

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. But 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.

DISCUSSION

Pedagogy

Gaunt and Westerlund (2013) argue for challenging established forms of music education and extending pre-existing realities. LoLa offers students greatly expanded possibilities for learning, rehearsing and performing with teachers and students from different institutions, disrupting the traditional master–apprentice model. 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. A piano teacher in this study shared this view, while some teachers and students expressed more traditional values, feeling that learning with different teachers could be 'harmful'.

Gaunt and Westerlund (2013) go on to argue for collaborative learning, including cooperating beyond geographical boundaries, and meeting new social situations and navigating cultural difference. LoLa allows students to form communities of practice (Wenger et al. 2002) and learn from each other. Students in the study were enthusiastic about learning from different musical cultures and backgrounds. 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.

The 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. For example, teachers could exchange students for one lesson every few weeks with no associated travel costs. LoLa also offers students opportunities for interventions from different teachers at an appropriate stage of their studies on an ad hoc basis, or, as part of an ongoing 'continuous masterclass'. Teachers could also benefit from observing their students learn from different teachers, and explore new ways of teaching to inform their own teaching practice and professional development (Duffy 2016).

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. Students reported wanting to experiment using LoLa for rehearsals, but also felt that they would prefer to rehearse face-to-face prior to a performance.

The Erasmus+ exchange programme was discussed in some detail. It was recognized that a major feature of the Erasmus+ programme was for students to be immersed in different cultures, an experience they would not achieve by studying remotely via LoLa. One possibility is for students to work with teachers or ensembles remotely for a period of time, and then travel to the other institution for a shorter and more intensive period of study or rehearsal. LoLa could also allow students to maintain contact with their principal teacher while studying abroad, while others may wish to maintain contact with their exchange teacher on their return to their home institution.

Participants discussed the benefit of having trial lessons via LoLa with potential new teachers to assess compatibility prior to committing to moving to a new city, whether as part of an Erasmus+ exchange, or for postgraduate study.

Technology

As reported by participants in this study, adopting new technologies in institutions can be problematic and may be met with initial scepticism. Brudvik (2018) states that there are four main factors that prevent the adoption of new music technologies: expense, accessibility, attitude and usability. These factors are often interrelated, but as Brudvik goes on to argue, the presence of just one of these factors alone can be enough to prevent implementation of new technologies. The LoLa software is free to use for educational establishments. However, the PC requires specific components and peripherals, which may make the cost of acquiring the LoLa technology prohibitive for some institutions. Furthermore, LoLa requires a high-capacity network and technical support, which affects the accessibility and usability.

Some of the reported disadvantages to using LoLa are also found in teaching situations using standard videoconferencing platforms. These include restricted movement around students, and not being able to physically adjust a student's posture or instrument. Many participants commented on how good the audio quality in LoLa was, but there were still limitations. Different instrument types have different problems in the virtual environment, as discussed by a technician in relation to string players needing to hear their own instrument as well as the remote player in their headphones.

The development of LoLa is dependent not only on technical improvements, but also on teachers and students giving feedback to help developers improve the system. The feedback from teachers and students participating in the study directly led to the development of LoLa 2.0. The updated version allows the use of up to four cameras in each location, allowing teachers to view students from different angles. Simultaneous performance is 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).

Limitations

Despite the new insights gained from the SWING project, it is difficult to make generalizations from this study and several limitations are noted. 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, and it can be difficult to conduct research projects in conservatoires with busy teachers and students. The students and teachers in the trial had a relatively limited experience of using LoLa. Furthermore, the research took place in 2019, a year before the pandemic of 2020, and the new working environment of conservatoires has radically changed since then.

Further studies

Further research could include longitudinal studies with students and teachers from a broader range of instrument categories, including brass and percussion, and also different genres, including jazz and folk/traditional music. Experiments 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. Further research could investigate recent technical developments of LoLa including multi-node interactions between three institutions, offering greater scope for masterclasses and group teaching between institutions.

CONCLUSION

The SWING project is a qualitative case study, exploring attitudes and mindsets concerning the use of LoLa. Participants in the study were drawn from a variety of locations and backgrounds and expressed a wide range of views, from traditional values, through to more modern and progressive beliefs.

The findings show that LoLa offers new opportunities for synchronous interaction between teachers and students in different institutions. LoLa can be used to facilitate trial lessons with a different teacher before embarking on a more prolonged period of study, such as in the Erasmus+ programme. LoLa can also be used to facilitate a continuous masterclass, where students play for a teacher in another institution every few weeks. Another possibility is that of a teaching exchange, where every few weeks, teachers simply exchange students for that week with no associated travel costs. In addition, students can also play and rehearse with musicians from other institutions, allowing greater opportunities for students to experience a broader range of musical cultures.

Some of the suggestions made by participants have since been implemented by the LoLa development team with the introduction of recording functions, multi-camera techniques and multi-node capabilities, allowing three institutions to connect. There were requests from participants to try to further improve the audio quality so as to be as realistic as possible, including attempts to achieve spatial sound. Whilst these technical possibilities increase the functionality of LoLa, there were also requests to make the system easier to use, so that musicians are independent from technicians. A major improvement would be the ability to operate LoLa over a standard network without the need for specialist technical support to navigate network firewalls. Another obstacle to the adoption of LoLa in institutions is the cost of the hardware. This is likely to fall due to continual improvements in PC graphics, sound cards and monitors, particularly from the gaming sector.

Many participants reported overcoming their initial scepticism and being pleasantly surprised once they had used the LoLa technology, particularly with regard to the quality of sound. Most participants expressed the view that the LoLa system should not replace face-to-face teaching, but that it could be a useful supplement. Many participants also expressed an interest in continuing to trial the technology.

In light of the ongoing restrictions on travel and the need to maintain social distancing, as well as the imperative to reduce carbon emissions from travel, I argue that the discussion on whether low-latency technologies can, or should, support instrumental teaching in conservatoires has moved on. I believe low-latency technologies have an important part to play in the teaching strategies of higher music education, and LoLa has been shown to provide an effective way of teaching between remote locations. LoLa can also facilitate remote working *within* institutions, particularly for vocalists, brass

and woodwind players, where there may be restrictions on rehearsing and performing with others due to the production of aerosols.

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