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MANAGING VARIETY TO ESTABLISH VIABLE VIDEOCONFERENCING IN REMOTE MUSIC TUITION FROM AN EDUCATIONAL TECHNOLOGIST'S VIEWPOINT

MA thesis

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Abstract

The thesis, titled “Managing variety to establish viable videoconferencing in remote music tuition from an educational technologist’s viewpoint”, addresses the problem of how educational technologists can balance variety in a manner which enables technology to be involved in the teaching and learning so that it enhances the experience as opposed to hindering it. To this end a case study was conducted where an educational technologist attempted to establish viable videoconferencing to facilitate remote music tuition. The key milestones of the case study were then interpreted in light of the Viable System Model (Beer 1979, 1981, 1985). This analysis revealed that videoconferencing in one-to-one remote music lessons is viable, if the varieties between the users and the tools is balanced. In order to achieve such a balance, the right variety handling strategy needs to be chosen to attenuate or amplify variety in the right places. To do this, the users’ needs as well as the appropriateness of tools available have to be assessed, and the teaching-learning experience needs to be monitored to learn whether the teaching-learning experience is at the desired level of quality and whether teachers and students are able to use tools self-sufficiently. A variety handler’s ‘compass’, which offers recommended activities to achieve or maintain balance, and thereby viability, is presented at the end of the thesis.

Keywords: educational technologist, VSM, viable system model, variety, variety management, videoconferencing, remote music tuition

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Introduction: Technology from the perspective of an educational technologist

At the very core of my vision of learning is the assumption that humans as social beings learn best in human-to-human interactions and active experiences. This leads me to the question, whether technology is an absolute necessity for learning in the 21st century and my answer is that it is not. Unless technology is used to amplify human-to-human interactions and experiences or to make them more accessible. Any non-human technology should be applied responsibly, by and in service of humans.

To me, there are three types of educational technology: organic (human), analogue, and digital. The first of these is of course the most critical one since learning is an acquisition process taking place within the individual, resulting in changes in the mind and the body. To be able to interact with and process incoming information, one needs organic 'technologies' like sensors and the brain, that is, a body. Therefore, a prerequisite for human learning is the presence of human technology. Why I have made this somewhat obvious point is that in my vision of learning one can apply any analogue (for example pencil and paper) or digital technology as long it amplifies learning and actually helps (or does not interfere with) the human 'technology'. In other words, in my view the 'analogue' and the 'digital' technologies need to stay in service of the 'human technology'. Such an approach to educational technology might appear conservative, but I see it as common sense suggesting us to keep emphasising the importance of the human factor, to prefer human-to-human interaction as the most natural and effective, and to carefully and responsibly design any human-computer interactions or computer mediated human-to-human interactions.

Amidst all the hype and marketing, one of the digital technologies that to me stands out as something truly necessary is videoconferencing. Becoming more and more available to organisations and individuals, videoconferencing, and even telepresence in some high-profile contexts, holds dear some of the core 'currencies' in my vision of learning—the human factor, conversations, social learning, flexibility. What is more, real-time conferencing can make human-to-human interactions and learning accessible despite geographical, temporal, sociocultural, or resource related challenges. However, it is to be applied only if any of such challenges are actually faced and not for the sake of 'innovation.' Last but not least, videoconferencing can save schools, universities and governments time and money which they

can invest in what is of the essence – people (students, teachers as well as support staff) who care about and, directly or indirectly, take part in meaningful learning experiences.

The present thesis came to be as a result of the need to make possible computer mediated human-to-human interaction of a certain quality, to enable remote music tuition via videoconferencing because of the student and the teacher being located in different countries. Thus, the current thesis presents an exploratory case study where an educational technologist, in a specific real-life context posing a geographical challenge, engages with facilitating videoconferencing between a music instrumental teacher and his student.

The purpose of the present thesis is to explain and exemplify how an educational technologist, involved in the aforementioned activity, is managing complexity in light of the Viable System Model (Beer 1979, 1981, 1985), a cybernetic model to help structure organisations and communications. To this end, specific milestones from setting up networked music lessons are interpreted in terms of the Viable System Model and used to exemplify and explain how an educational technologist is engaged with handling variety to reach a viable solution.

The thesis consists of four chapters. ‘Conceptual ground’ gives an overview of the theoretical framework the thesis proceeds from, explains some key concepts as well as outlines relevant background and previous research on the topic. ‘Methodology’ contains a description of the data used and the methodology applied, while the subsequent chapter, ‘Findings’, is devoted to presenting findings from the data collected. ‘Discussion’ provides the application of variety management theory on highlights from the data, demonstrating how the findings of the case study can be interpreted under the conceptual label “variety handling”. The thesis ends with a conclusion where the most important results are outlined.

Conceptual ground

While digital technology is often portrayed as what allows teachers and learners to make their work more effective, very often what in fact occurs is that the adoption of new digital technologies into educational processes also brings about an explosion of complexity. There are increasingly more and more tools that could in theory be used to assist teaching and learning. However, the frantic and rapid pace at which new tools and services (and options) are introduced, can have a disruptive effect on the teaching and learning practice. To

counterbalance, the role of an "educational technologist" has been emerging since the 1990s. (Davidson, 2003) However, defining the role of an educational technologist is not a clear-cut endeavour (Davidson 2003, Lorenz, Kikkas & Laanpere, 2014). Lorenz et al. clarified the profession to disprove notions where an educational technologist is interpreted as a side role of an ICT support or designates "a technology-savvy teacher who could take responsibility for teaching with technology in some subject domains so that the rest of teachers would not have to bother them with constantly changing landscape of technology" (*ibid*, p. 288). While Lorenz et al. clarify and justify the role of an educational technologist to school principals, the current study complements by further investigating the role.

In a broader sense, the educational technologist is a person helping teachers and other educators to navigate the "mess" created by the multitude of tools and services available. If we look at what an educational technologist like me faces on a daily basis from the point of view of managerial cybernetics (Johnson, 2017), then what we have to address is managing or handling complexity or, to stick to cybernetics, variety. This is often overlooked in favor of a black-and-white vision that sees technology in terms of what works and what does not, or what is effective and what it is not. For example, Biesta (2010), however, criticizes this perspective, as he sees educational research committed to much more than just pointing to what works and what does not. In addition, more closely to educational technology, the likes of Oliver (2013) and Selwyn (2016) call for a more thoughtful approach to technology in education, to put technology into the broader context of educational research adding theoretical depth to our analysis of how technology can be incorporated into education. In the context of the present work, the black-and-white approach is of little use when analysing the main issue here, which – enriched by theoretical depth – has to do with how to handle all the variety involved, in order to strive towards technology use that enhances teaching and learning. This is the main research problem that this work is going to address.

What (and where) is variety and how to handle it?

To provide an answer to the question above, and orient our general investigation, Stafford Beer's Viable System Model (Beer, 1984) provides a thinking tool. Known to many as an author and consultant in managerial cybernetics, Beer (1983) has stated that the starting point of the Viable System Model (VSM) is human potential. The VSM sets out to explain how systems are viable—that is, how an organism or organisation is capable of maintaining its existence

independently of other such systems within a shared environment (Beer, 1984) The model is used for diagnosing and designing organizational structure and communication to facilitate necessary and sufficient conditions for viability. (Nyström, 2006)

Figures 1a and 1b are two variations on presenting two simplified takes on the VSM. Figure 1a depicts a viable system within its environment and management within a viable system while the size of the three elements is conveying a message of difference in the amount of complexity involved in one or another. For an example, the educational system can be thought of as the ‘viable system’ and the society as the ‘environment’. The variety of the environment is much larger than that of the viable system itself. And the variety of management is much lower than the variety of the viable system itself. (Espejo, 1989) Basically, what we have is a situation of unbalanced varieties.

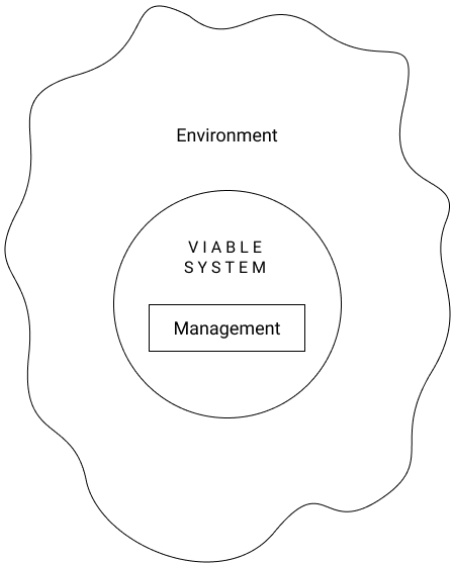


Figure 1a. Viable system in its environment. (Espejo, 1989, p. 79)

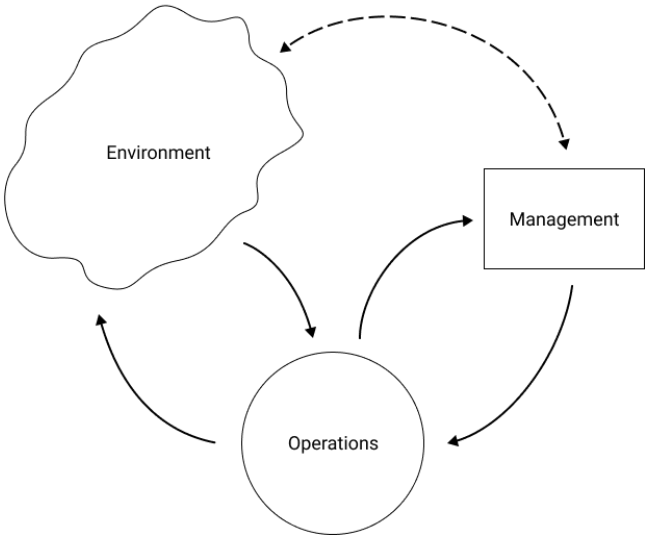


Figure 1b. The simplified organisational VSM. (Adapted from Beer, 1985, p. 27)

On figure 1b, to serve the visualisations presented later on in this investigation, the viable system is moved out of its environment and the management out of its viable system. This way, on figure 1b, the viable system is composed of the operations (circle) and its management (rectangle). The arrows represent interaction, flows of information between the ‘elements’.

Beer has touched upon the VSM in several of his works (see for example 1979, 1981, 1985). Other authors, both in managerial cybernetics as well as other fields, have interpreted and built on his work. Leonard (2005, p. 1), for example, interpreting Beer and the VSM, has suggested that "if there are accepted criteria of performance, [the VSM] can be used to diagnose whether the management infrastructure is well adapted to fulfil its duties and where there are gaps or lags". In the context of the present thesis, the "accepted criteria of performance" can be seen as viable remote lessons and the "management infrastructure" can be interpreted as the human and material resources, equipment, etc available for the remote lessons. The model, thus, should enable one to analyse whether the infrastructure is sufficient for conducting successful remote music lessons.

A central position in the VSM is occupied by the Law of Requisite Variety (Ashby, 1957) stating that to control a complex system, the controlling system must generate at least as much variety as the system being controlled. In other words: only variety can absorb variety. Variety, as phrased by Ashby (1957), is the measure of complexity in a system, defined as the number of its possible states. If varieties in a regulatory 'relationship' are disbalanced, the system cannot attain stability. Assuming that the regulator has the smaller variety, there are only two ways of meeting the demand of requisite (matching) variety. One is to attenuate variety in the system (systemic variety), the other is to amplify variety in the regulator (regulative variety). These strategies can be mixed. (Beer, 1974) It is normally expected that the system under regulation is more complex than the regulator. If not, the situation should not be subjected to variety management.

To further explain the VSM as well as where and how an educational technologist might be handling variety, figure 1b, the simplified organisational VSM, is developed further. Figure 2 can be interpreted as an example of a situation where an educational technologist is 'installed' as a channel in the bi-directional 'flow' of information either between school management (the square) and operations – that is learning and teaching (the circle) – or between the operations and the environment.

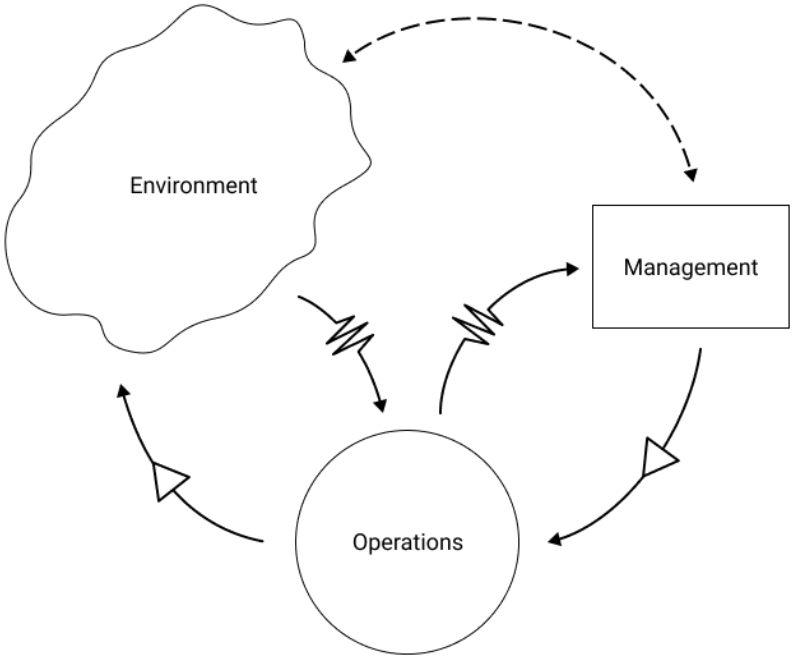


Figure 2. The simplified organisational VSM with variety attenuators and amplifiers installed. (Adapted from Beer, 1985, p. 27)

The educational technologist's role as a channel is, on the one hand, to reduce variety (indicated by the the zigzags in the middle of the two 'flows'– from operations to management and from the environment to operations). This can be done, for example, by doing some research on or testing tools and only then presenting teachers and learners with an informed choice. The educational technologist can also assist the operations by filtering out or helping absorb the advertising and hype coming from the environment (the blob). The outside environment includes businesses and agencies 'bombarding' both the operations and management with massive flows of information.

In a successful organisation, the educational technologist is also expected to amplify the variety of operations (see the triangle placed in the middle of the line), for instance by facilitating purposeful and skillful use of information and communication technology (ICT) via consultations, discussions or trainings. This way, users are more likely to embrace a meaningful and smooth use of ICT. All in all, the organisation is more viable, adaptive to change.

Handling variety means to understand when and where to reduce (attenuate) variety in the system being regulated, and when and where to amplify variety in the regulator. Often the

two strategies are mixed. All this is done to balance the varieties in the two parties in the bi-directional 'flow', the regulatory relationship. Of utmost importance is to understand that the variety-balancing act is bound to fail if attenuating or amplifying is done in the wrong direction of the two-way flow between management and operations. For example, it is important to avoid attenuating variety in the regulator by, for instance, cutting the likes of discussions and trainings, and amplifying variety in the system by 'bombarding' the operations with every possible tool and option in ICT, adding to complexity where it cannot be absorbed at the other end. These are no options for an organisation aiming to remain viable.

To emphasize the effect of variety handling capability on the viability (and autonomy) of a system or an organization, let me quote—and build on in square brackets below—Britain and Liber (1999: 24):

> 'There also need to be communication channels that permit self-organisation and allow different operational elements to interact with each other without involving management. Self-organisation allows the operational elements to soak up much of their own complexity. [...] Self-organisation amongst sub-systems in an organisation can reduce the load on communication channels with the management without having to introduce a fixed hierarchical architecture.'

Here the communication channels could be interpreted as an open-minded educational technologist and the different operational elements can be thought of as a teacher and student. When the operational elements, that is the teacher and student, are able to self-organise and "soak up their own complexity", they will hopefully be able to "do their thing" without an educational technologist in the future, so that the educational technologist could amplify other operations in the System too.

Applications of the Viable System Model

Orengo (2018) suggests that the VSM is a niche 'tool'. In his study based on observations from practical applications of the VSM, systematically collected by him, he states that VSM is not known by many, it is rarely used in practice (compared with the instruments of classical organization theory), and it is not taught systematically in management programs, whether they are academic or not. (*ibid*) Orengo's work is geared towards a 'smoother pass from the early adopters to the early majority.' (*ibid*) To that end he suggests 'not to overstretch the VSM as "the better organization method". Instead, the VSM should be refocused on the rather abstract

balancing of varieties.' (2018, p. 269) The current study contributes to Orengo's call for a wider application of the VSM, for variety handling is exactly the theoretical niche it is aiming to put in practice.

Regaliza, Jiménez & Arranz Val (2017) have also taken a look at the breadth of application of the VSM. The authors have listed more than 50 studies spanning from 1979 to 2016. Out of these studies only four have been identified as applications of the VSM in the 'Education sector'. Three of them are in Spanish (mostly dealing with managing educational institutions), and one in English, but none of them are closely related to the topic of the present thesis.

As for applying the VSM in research on educational communication and technology, it is a rare combination. Discussing viable "ways of being" with technology, Johnson and Liber (2008) are perhaps closest to the spirit of the current work. Authors present the Personal Learning Environment as a practical intervention concerning the organization of technology in education. Using the VSM, they identify different regulatory mechanisms that are responsible for maintaining viability for learners, and how physical engagement with tools is of fundamental importance in learners being able to manage their learning environment. While Johnson and Liber (2008, p. 4) were most concerned with 'how the learner can steer themselves in a complex technological domain', the current work adds to how an educational technologist could help and foster where needed, by helping students and teachers navigate the influx of tools so they could focus on the learning and teaching process as much as possible and release their individual potential.

Rewinding another decade, Oleg Liber stands out as one of the pioneers of considering learning technologies through the lens of the VSM. Liber (1998), having used the VSM for analysis, has called for a redesign in education structures if the promise of new learning technologies is to be realized, along with the development of new technological tools for the management of learning. A year later, Britain and Liber (1999) introduced, based on the VSM, a cybernetic model for evaluating virtual learning environments (VLEs). Authors chose the VSM as an organisational systems approach 'because it is essential to understand that when one decides to change one element in a system (such as the teaching and learning process by introducing new software), it is necessary to consider the impact on other elements of the system.' (1999, p. 3)

The two applications of the VSM referenced above exemplify well an important characteristic of the VSM, the principle of recursion, which states that any viable system contains, and is contained in, a viable system. Or, as Leonard (2000, p. 711) puts it, ‘each independent viable system is embedded in other more comprehensive systems’. Britain and Liber (1999, p. 25) explain the importance of recursiveness: ‘The VSM is particularly powerful because it suggests that organisations can be seen as consisting of smaller BUT POTENTIALLY VIABLE organisations, working together to achieve mutual benefit.

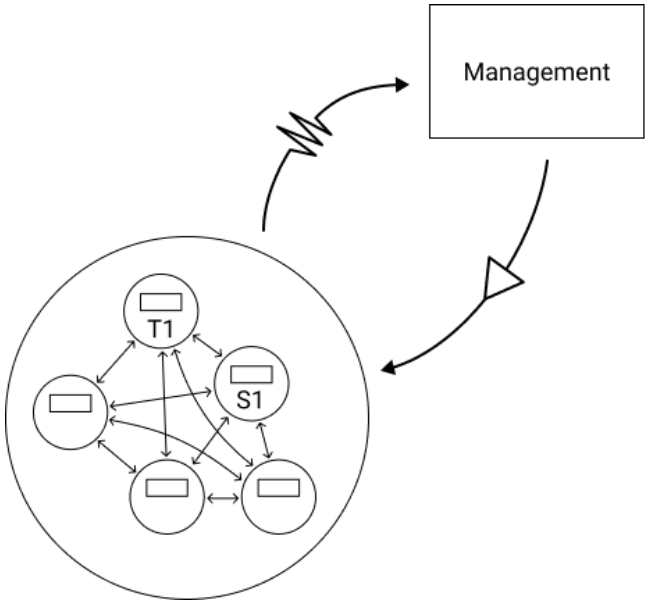


Figure 3. A simplified VSM of a school. Two viable systems (a teacher, T1, and a student, S1) pinpointed inside operations, next to other viable systems. (Adapted from Beer, 1985, p. 27)

Figure 3, another simplified take on the VSM, illustrates the recursiveness of the VSM. At recursion level ‘school’, the figure presents the management (in the rectangle) and the operations in the circle. If we “zoom in”, to a lower level of recursion, we find within the operations (the big circle) smaller circles that represent a teacher and a student who, in turn, are viable systems. In fact, every learner and teacher can be viewed as a self-organising system. The quality of their self-organisation is dependent on their own variety-handling capability and that of the system they are a part of. The latter is the reason why a school needs, among other experts, an educational technologist capable of handling variety the right way (as discussed earlier in this section).

Britain and Liber (1999, p. 24) have listed a strategy that resonates with my approach to the role and impact of an educational technologist: ‘One way to approach managing complexity is to look for ways in which operations can become self-managing while remaining within the overall guidance of management. This requires a number of communication channels between management and operations for specific tasks. These include: resource negotiation, coordination, monitoring.’ Such labels for tasks have more to do with the school level of recursion where the management would install people or tools between itself and the operations so that the latter, as well as the school in general, could be viable.

The empirical base for the current case study, however, operates at a lower level of recursion, “zooming in” to the operations, wherein two ‘units’ (teacher and student) interact one-to-one, as two viable systems. Every viable system, as discussed earlier, has its purpose, people and variety, as well as their own ‘agenda’. In education, every teacher and learner is a unique person with his or her idiosyncrasies. Naturally, interaction between them is a source of complexity.

On defining a regulatory relationship for analysis

It is important for the sake of focus and self-containedness of analysis that a relevant VSM recursion and regulatory relationship(s) were chosen when embarking on an investigation on variety management. It is the regulating system that defines the set of variables desired in the system under regulation (Waelchli, 1989). As for this case study, if I viewed the educational technologist as the regulator and lessons as the system being regulated, we would be dealing with a somewhat technocratic situation, where it is not the educator defining the setting desired in his/her lessons, e.g. tools and methods one needs to make learning happen. That is to say, if the ‘equation’ had system Teacher regulating system Student, this would allude to a hierarchical relationship which is in my opinion undesirable in modern day schools and universities.

However, this does not mean that such a regulatory relationship could not be applied for mapping and discussing variety ‘engineering’ in an educational context. For example, Britain and Liber (1999, pp. 25-26) applied the VSM to a university course and viewed the teacher as ‘facilitating, resourcing, co-ordinating and monitoring’ learning, undertaken by students as workers in an educational enterprise. Hypothetically, if that example was followed in the current thesis, we would be pinpointing and discussing where an educational technologist attenuated or amplified variety based on the set of ‘variables’ (the change) the teacher would like to see in the

learners. Although such a balancing equation makes complete sense, it is not the best fit for this particular case study since it has more to do with pedagogy and managing the student's learning progress than finding an optimal ICT setup for networked lessons.

That is why I'm applying a different equation. Videoconferencing implies that the system being regulated is a set of tools allowing both the teacher and student to operate in a common system, the 'Lesson'. Hence, the regulator in this context are the student and teacher together as 'Lesson', regulating the system 'Videoconferencing' (VC). It would not fit the context of this case study to view the teacher alone as the regulator. Since system 'VC' is there to create (or mediate) a common space, where the two participants are interdependent on changes in variables at either end, in my equation it is important to have the teacher and student cooperate in 'Lesson' defining their desired variables in 'VC'. Effectively, in the VSM of a remote lesson in the context of this case study, the teacher and student together can be viewed as management and 'VC' as operations (figure 4).

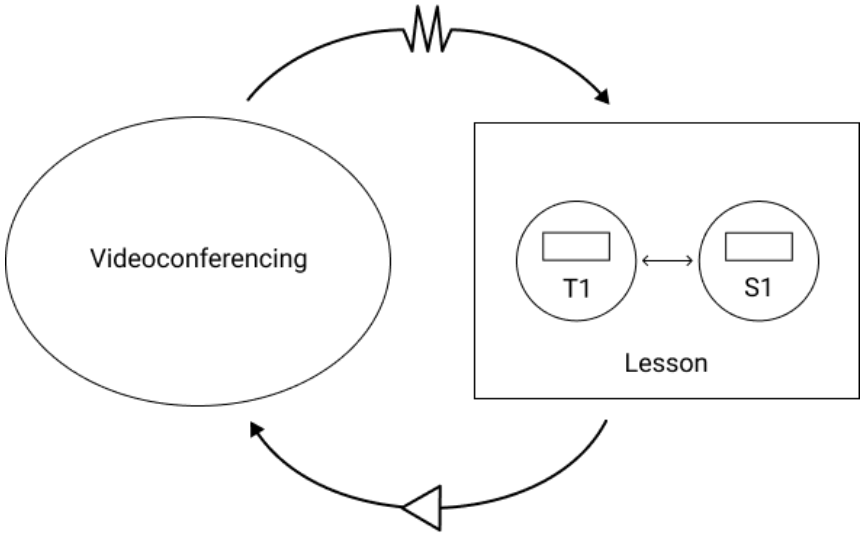


Figure 4. The regulatory relationship for this case study. system 'Lesson' (containing the teacher and the student) regulating the system 'Videoconferencing' (VC). (Adapted from Beer, 1985, p. 27)

Orengo (2018, p. 264) has observed that a variety of approaches tries to make the VSM "easier to understand". In essence, the approaches of this type try to explain the VSM theory through down-to-earth examples. An example of such an approach is a rather accessible

application of the VSM by Leonard (2005), whom I built on earlier in this section. She (2005, p. 2) exercises the model as 'The Personal VSM' of a full-time student in a university. '[It] is an example of a VSM of an individual's life. It is a setting that everyone can relate to and that is useful as a self-referential tool. One's life is also an example that provides illustrations of how some of the same activities may fulfill different functions in different people's lives, or in the same people's lives at different times.' Leonard's interpretation of the VSM exemplifies well its universality. Orengo (2018) welcomes the practitioners' and the users' perspective to the VSM community, complementing the academic bias. Thus, the current case study contributes as a practitioner's take on the VSM.

Research on videoconferencing in music education

Since the empirical 'feed' in the current study has to do with examples from managing videoconferencing in distance music education, I find it appropriate to mention that, for a better orientation in the field, a body of literature and reports on networked music performance, rehearsal or tuition was consulted. I have listed and categorised the papers and reports consulted in Appendix 1 but will not be providing an overview of them here as they do not directly contribute to the aim of this thesis.

To summarise briefly, since the late 1990s several studies have been conducted investigating the feasibility, requirements and effectiveness of networked music performance, rehearsal and tuition. While aspects like the advantages and drawbacks, presence, distance, eye-contact, audio and picture quality, network connection, audio-video equipment, participant as well as audience perceptions and recommendations have been laid down by a couple dozen researchers, what has been seldom addressed in more than a few sentences is the role of 'management' in keeping viable such telepresence or videoconferencing operations. Penalba et al. (2011) and Nakai (2012) stand out as exceptions in this regard. However, in none of the studies consulted has a cybernetic model been applied to map and discuss variety and variety handling in a specific context.

It must also be noted that data in the current study derives from managing variety and viability in the 'subdomain' of remote one-to-one lessons, and not in that of networked masterclasses or performances, which, with their specific requirements – for 'stage' production as well as for researcher data collection – invites further studies explaining variety management through down-to-earth examples.

Methodology

As laid down in the introduction, at the core of this case study is exploring how an educational technologist, in a specific real-life context, engages with handling variety to facilitate viable videoconferencing for remote music lessons.

Late September, 2017, an accordion student at Tartu Heino Eller Music College turned to me, the educational technologist at the same school, saying he and his teacher have lessons scheduled for the 2017/18 school year but they are facing a geographical challenge, as most of these one-to-one instrumental music lessons have to take place between Ålgård, Norway and Tartu, Estonia. They would regularly have face-to-face lessons, too, in Tallinn, but the majority of lessons would be remote. During September they had tried using Skype in a few sessions but had had technical problems and were not happy with the sound quality. The student asked for my assistance in finding a better solution, something they could work with. As a matter of fact, I had been a protagonist of videotelephony as a means of bringing people together while saving precious time, money and the environment, but had not had a push to dwell on the matter in a specific setting with its people, purpose(s) and, needless to say, variety. What also motivates me is when ICT is deployed to address a specific need or challenge, deriving from the very operations in an educational setting. Thus, I agreed to explore and find a setup in collaboration with the teacher and student that they could work and be happy with. The people involved were an accordion teacher, his student, myself as the educational technologist, and the sound engineer at my school whom I asked to join as someone who is better versed in sound, microphones and other audio equipment. We set out to do something I can now label as managing variety to establish viable videoconferencing in remote music tuition.

The research methods in this case study are participant observation and semi-structured interviews. The agreement between the teacher, student and myself, when we started out in October, was that I could (quietly) sit in the lesson, interfering as little as possible and conversing with the pair only at the beginning and end of a session, unless they specifically addressed me during one. In this light, participant observation as a method for data collection best suited the context. Whenever possible, I would be physically present at the student end of videoconferencing, setting up or helping to set up equipment and starting the videoconference

with the teacher end. Once a lesson started, I was observing, taking notes and photos, making video recordings. In addition to the photos I took and video clips I made, whenever we used the Zoom[1] videoconferencing service I could conveniently record the whole lesson. All that to better understand what works and what does not for the two accordionists and where I could help improve their experience as soon as possible. Whenever I was able to observe a lesson and the two participants had time, the three of us would have a post-lesson discussion.

Altogether, between October 4th, 2017 and April 13th, 2018, I was able to document 11 lessons and be physically present at the Tartu end in eight of them. On one occasion, on March 31st, when the student took the lesson from his Pärnu home, I observed the lesson online. All sessions ran at about 90 minutes. Table 1 provides an overview of the types of data collected in the 11 remote lessons documented.

Table 1. Types of data collected in remote lessons.

Lesson / Data	4.10	3.11	17.11	12.01	26.01	2.02	9.03	21.03	31.03	6.04	13.04
Observation	X	X		X	X	X		X	X	X	X
Participant comments	X	X	X	X	X	X	X	X	X	X	X
Photos	X	X		X	X	X		X	X	X	X
Video clips	X	X		X	X			X	X		X
Full lesson video rec.				X	X	X			X	X	X
Setup spec.[2]	X	X	X	X	X	X	X	X	X	X	X

To document technical setup details and collect my notes as well as post-session comments from the pair, a collaborative Google Document was created during the first lesson and shared with the group. When I was occasionally unable to attend a lessons due to other commitment, the student filled in a brief technical questionnaire in the shared document and added notes on how the lesson had proceeded. The technical information that we always put down was a list of equipment used and internet connection parameters at both ends. From the

[1] zoom.us
[2] Technical setup details.

very start we also had a Google Hangouts group chat between the four people involved. The group chat was mainly used to coordinate lesson times, locations and the equipment used.

In addition to observations, notes from the discussions and the information on the set up list, various video material also turned out to be a wealthy source of insights and data. Despite having observed most of the remote lessons live, as they happened, it was the recordings that enabled me to discover additional facets related to both auditory and visual interaction, including instant reactions or comments when the emotion was still 'hot'.

In pursuit of more in-depth feedback, perceptions and reflections from the teacher and student, they were also interviewed individually on two occasions (see Appendices 2 and 3 for interview questions). The interviews were necessary for the following reasons. Firstly, quite often the post-lesson discussions were brief, since the student and/or the teacher would have to rush to their next commitment. Secondly, post-lesson group discussions would not reveal as many individual perceptions that one-to-one interviews to a neutral observer did. I conducted an interim interview at the beginning of February and the final interview at the end of April with the student and in early May with the teacher. The final interviews were conducted once we had achieved an optimal setup for remote lessons. While the interim interview served more as a quick checkup on the situation we had reached by then, the final interview was more structured to be able to collect insight and status evaluation on as many facets of variety in videoconferencing (previously spotted or not) as possible. This data also contributed to defining what constitutes 'viability' for the two musicians involved in remote tuition. In designing the final interview, I built partly on Nyberg and Berg's (2014) questionnaires and interview guide developed to gather descriptions of perceived qualities of audio and video in distance music education.

Where the interpretation of a certain instance in one of the interview responses or other findings required double-checking, I contacted the teacher or student via Google Documents and received clarifications. The latter applies also to where I asked the sound engineer to review some of my interpretations regarding audio equipment and quality.

What is more, while all the lessons observed were real-life situations, on April 20th I organised a special session where the sound engineer recorded the student playing the same brief piece of music to different microphones and varied settings in the Zoom videoconferencing service, so we could later compare the sound quality of different takes and settings. Following the same setup pattern, the sound engineer also recorded himself playing the acoustic guitar

which provided us with ‘control’ data. On April 27th the sound engineer and I had a listening session to compare the takes.

Analysing real-life examples from the collected data in light of the Viable System Model and variety management strategies will allow me to explain how variety can be handled in a specific context, on the VSM recursion ‘remote lessons’ and in the regulatory relationship where system ‘Lesson’ (comprising the teacher and the student) is regulating system ‘Videoconferencing’ (VC). The analysis described above will lead to an attempt on defining what is ‘viable’ in this particular context.

Findings

Based on data collected over the course of seven months, this section outlines the challenges met in remote music tuition in the context of this case study. Our responses to these challenges will also be described.

From what I have observed and gathered from my informants, essential operations in one-to-one music instrumental lessons have to do with playing to each other or together, listening to yourself or the other playing, showing your playing (e.g. hand or fingers positioning), watching the other playing, and talking or conversing (e.g. instant feedback). For a clear and systematic approach, these ‘domains’ are built on to present examples of variety in remote lessons.

Student playing, teacher listening

The core of one-to-one music instrumental lessons is the student playing to the teacher so that the teacher can assess the playing and give feedback. In the final interview the student said that there have been no constraints to his playing in remote lessons. He has had the liberty to play just like he would in face-to-face lessons. However, remote lessons do pose a challenge concerning whether the sound gets across to the other end, and if it does, whether it is of acceptable quality or not. This was one of the domain that me and the sound engineer helped the student to manage. In short, I can summarise from our explorations that in order to produce and mediate sound of acceptable quality you would need to take care of three core areas: an external microphone, a suitable videoconferencing service, and a stable internet connection (preferably wired if possible).

The microphone component at the student end provides a clear example of where I saw I had to reduce variety in the system. It was in March when I asked the school to purchase a USB microphone because by then we had learnt the hard way about why it would be worth the investment of about €200, and how it could make remote lessons easier to manage. The USB microphone made setting up a videoconference significantly easier and faster at the student end. While a USB microphone is connected directly to the computer, previously we had to connect a microphone to an external audio interface (a sound card) which was then connected to the student's computer. Switching to a USB microphone made preparations for a remote lesson less stressful and more convenient for the student. Previously there had been occasions where the school's Focusrite 18-in-channel audio interface would be too complex for the student to manage on his own (March 9th), or the same device would be unpredictable as to whether it would work in Zoom on different computers, thus causing loss of time at the beginning of lessons (January 26th and February 2nd).

Since it turned out we cannot be certain about a device working like 'plug-and-play', we first switched to another, more simple Audient audio interface that the sound engineer brought from home (March 21st). It was around that time when I continued my lobby for the USB microphone and had it finally purchased for the school. The specific model (Rode NT-USB) was something that the owner of Lesono[3], a videoconferencing service designed for music instrumental tuition, had recommended to me in an e-mail exchange as their number one pick among different USB microphones. The Rode microphone was a successful addition to the setup already from its first outing on March 31st when the student participated in the lesson from his Pärnu home. I gave him the microphone to take with him so he could get familiar with it and use it as soon as possible, i.e. in the Pärnu session. The USB microphone has proved it can increase student self-sufficiency in managing remote lessons where he would not have the educational technologist or the sound engineer available for technical support.

The quality of the sound produced was of course for the receiving end, the teacher, to evaluate. Looking back at the whole process, from when we started in October the teacher has not been expressing criticism of the quality of sound he received in remote lessons. He usually commented on the sound as being 'very good.' However, based on my observations and having re-listened to what some of the videoconferencing audio sounded like, I take it that he as an experienced accordion teacher would be more concerned with the sound or tone quality only

[3] lesono.com

after a student has made certain fundamental progress in instrument or repertoire mastery. The teacher concurred with this interpretation. When asked in the final interview about the sound quality in the last two remote lessons where the student had the USB microphone and Original Sound was turned on in Zoom, he said he was happy with the sound, as it is natural and all frequencies are coming through.

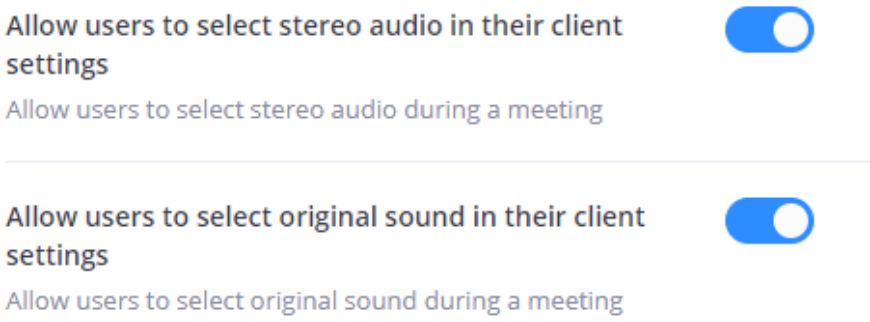
Teacher playing, student listening

Similarly to the student, the teacher also found (in the May 6th interview) that compared to face-to-face lessons there were no constraints to him playing his instrument in remote lessons. As was the case with the student playing and the teacher listening, the variety to handle here had to do with the quality of sound that was put into 'the machine' and reached the student. What I observed and discussed with the student after two lessons on Zoom in January is that although most of the playing in the lessons is done by the student (for the teacher to assess and give feedback on) it is also important that any playing done by the teacher – be it corrections or examples – would came across as naturally as possible for the student to understand and process. Until February, the teacher had played into a microphone integrated into his iPad or Windows laptop. It was especially in the January 12th and 26th lessons where the student said he is not happy with how the teacher sounded via Zoom. The audio volume was automatically turned down in Zoom when the teacher was playing loud. In order to ascertain whether it is Zoom´s audio enhancement which is interfering with the sound, we wanted to rule out the teacher's iPad microphone as the culprit. To this end, we asked the teacher if he could join the next remote lesson (February 2nd) using an external microphone and audio interface connected to his Windows laptop. He could do that, and this particular lesson on Zoom confirmed that you can have the best audio equipment connected but a speech-oriented videoconferencing software will turn your sound into something tinny and distorted, or in other words, it will kill the music.

As a consequence, I suggested to the group that we change videoconferencing softwares and give Lesono one more try. It is after all a videoconferencing service designed specifically for music tuition. Unlike the last time we had used Lesono (November 17th), the teacher end now too had proper audio equipment so we hoped that the lessons too would be more successful in terms of the improvement we were looking for. We used Lesono for the next two lessons (21st and 31st March) and our main finding was that the sound quality was better than we had previously experienced on Zoom. While observing the 31st March session online, with

my headphones on, I was still not convinced about the sound quality being as good as it could be. Thus, I came up with the idea of asking the Zoom support team if they maybe have something similar to Music Mode (Polycom, 2011) which is a feature of Polycom videoconferencing that I had spotted when working with literature for the current thesis.

Another reason I had not given up on Zoom yet was the student's feedback on its picture quality which he had perceived as better than that in Lesono (findings on image quality will be discussed later in this section). I decided to delve into Zoom's advanced settings and happened to chance upon the option to allow users to select 'original sound'. To find out more, and started, *via* zoom.us, a live chat[4] with a support representative, asking her whether the newly found feature would be something like Music Mode on Polycom. She advised that Preserve Original Sound would be my best option in that regard, and shared a link to Zoom's web page which states that the Original Sound option 'allows you to preserve the sound from your microphone without using Zoom's echo cancellation and audio-enhancing features.'[5] In this vein I also found the option to allow users to send stereo audio during meetings if one's microphone can process audio in stereo. The sound engineer and I tested Zoom's Original Sound with him playing the guitar and we found it worthy of taking it to the teacher and student for the next lesson, on April 6th.



Zoom's Original Sound mode discovered. A screenshot from March 31st.

Having had a listen to what the Original Sound feature does on Zoom confirmed that what we had not been happy with on Zoom in January and early February was one of the

[4] Loosely retold from chat transcript with zoom.us (31 Mar 2018, 05:53 PM GMT).
[5] From: https://support.zoom.us/hc/en-us/articles/115003279466-Preserve-Original-Sound [last accessed 22 May 2018]

audio-enhancing technologies,automatic gain control (AGC), which we now turned off. AGC is included in web conferencing services to improve the user experience in bi-directional voice calls and it ‘compensates for either audio or video input level changes by boosting or lowering incoming signals to match a preset level.’ (Polycom, 2011, p. 6) For the student this meant that the natural dynamic range of music played by the teacher was destroyed when using Zoom without Original Sound. From our experience Lesono seems to have AGC disabled by default, but it was not until the April 6th session when we turned on Original Sound (thus manually disabling AGC) on Zoom when the student was for the first time fully satisfied with the sound quality. He confirmed in the April 30th interview that sound-wise everything that could or should come through, is now coming through thanks to Original Sound. Since the teacher concurred, we decided to continue using Zoom after two successful lessons in April with the Original Sound turned on at both ends.

The sound engineer was also satisfied with what the Original Sound feature can allow. In the April 27th listening session where he and I listened to different sound samples we had recorded a week earlier, he reported no major difference in sound quality when comparing audio recorded in a Zoom videoconference to audio recorded directly to the computer. Hence, it has been a twisty but exciting path reaching a stable state in just one, yet one of the most important variety domains for musicians.

What was gained from the lesson on February 2nd after which we decided to move from Zoom back to Lesono is that ever since then the teacher has been using an external audio interface, a mixer and several microphones – one for right hand play, the second for left hand play and a third for talking – in remote lessons. The mixer and the two microphones are the same audio gear he uses as a performing artist. In the final interview the teacher said that when he is in remote lessons it is somewhat like working in a recording studio. He indicated that he enjoys monitoring his own playing on the headphones in remote lessons and, if need be, adjusting his own sound which is made up of elements like a certain balance between left and right hand levels as well as sound effects that one can choose and apply from the mixer (for example echo).

Another challenge under the ‘teacher playing, student listening’ domain relates to the medium for listening, that is headphones or speakers. Unlike his teacher, the student prefers not to wear headphones when in a lesson, because headphones hinder him from properly playing the instrument. With headphones on he cannot hear the details of how his instrument sounds in

the room that he is in. Thus, headphones limit him from listening to and assessing the full ‘feedback’ from his instrument while he is playing. In the April 6th lesson, he would put headphones on or hold them by his right ear every time the teacher talked or played him something and he would put them aside before he himself started playing. It was inconvenient and somewhat messy for the student.

April 6th. The debut of Zoom’s Original Sound.
The student having to manage headphones for incoming audio.

In addition to being inconvenient, having to manage headphones can potentially also hinder the interaction and learning. I spotted in April 6th lesson an instance where the student was about to start playing and the teacher wanted to specify his instructions but since the student had already put headphones aside, he could not hear the teacher. Nor could he see the teacher with his eyes already on the keys. Four minutes later the teacher noticed (and mentioned) that the student had lost his focus when finishing a piece of music because he had already been thinking about grabbing the headphones, in order to receive the teacher's feedback. The student agreed about having had that distracted moment. Hence, our challenge for the next lesson at the student end was to try and facilitate listening on speakers while avoiding anything from the speakers being caught by the microphone and thus ending up back at the teacher’s end (audio feedback). Usually, in voice calls such feedback is countered by built-in echo cancellation

technology. However, as mentioned earlier, turning on the Original Sound mode in Zoom disables, alongside other audio enhancements, the echo cancellation.

Thus, with the Original Sound mode on, on the one hand I was able to find and open ‘channel’ for audio to be passed along (in both directions) exactly how Zoom receives it while on the other hand I created (and accepted) a new challenge of optimally positioning the speakers and the microphone where a headphones-free situation is desired. In our first run (on April 13th) with such a setup the teacher reported only minor audio feedback looping back to him when he was playing. He did not find it disturbing. Other people may not be so tolerant though. What contributed to the relative success of piloting headphones-free monitoring was that the student’s favourite, easy-to-use Rode NT-USB is a cardioid microphone, meaning it captures sound less on the back and sides and more from the front. Hence, all we had to do was to make sure the speakers are located far enough behind the microphone. Ideally, this setup would need to be put to the test in more sessions so we can assess its viability and elaborate the do’s and dont’s of headphones-free videoconferencing with echo cancellation disabled.

April 13th. The student freed from headphones.

Teacher and student talking, conversing

Based on my observations I found that conversations between the teacher and the student, especially towards or at the end of a lesson, is another natural part of their cooperation in lessons, creating a safe atmosphere and building the relationship between the master and the

apprentice. While the conversations have not been hindered by technology in remote lessons, the teacher outlined in the final interview that talking to the student has not been working for them as well as it has in face-to-face lessons for the reason already presented in this section – the student prefers not to have headphones on when he plays the instrument. As discussed earlier, although the April 13th lesson yielded promising results, I will, together with the sound engineer, continue establishing a viable solution for headphones-free monitoring for situations where echo cancellation is disabled in the videoconferencing service for the sake of audio that is as unprocessed as possible.

Teacher and student playing together

In the final interview the teacher outlined that playing together with the student has been a natural part of his face-to-face lessons and it is the only area where he has had to adjust his teaching for remote lessons since it has not been possible to play together in real-time. This is due to latency (or delay) generated by network traffic, the videoconferencing service and equipment involved in the session. The delay we have experienced in remote lessons on different services has varied between about 0.5 and 1.5 seconds. The teacher also stated that if he could play together with the student in remote lessons, to him there would be no difference between face-to-face and remote lessons. After further exploring the menus on Zoom and having consulted one of their support representatives, I tried to minimise latency by setting up a Peer to Peer connection on Zoom between the teacher and the student for the April 13th lesson. The idea of Peer to Peer connection on Zoom is that it allows users to directly connect to one another in a two-person meeting. Unfortunately, the effect of a direct connection between two ends of a videoconference did not materialise, at least not at first attempt. When trying to play together, the teacher and student experienced the usual latency that they have become used to. They were not able to tell in more detail but estimated the delay at about one second.

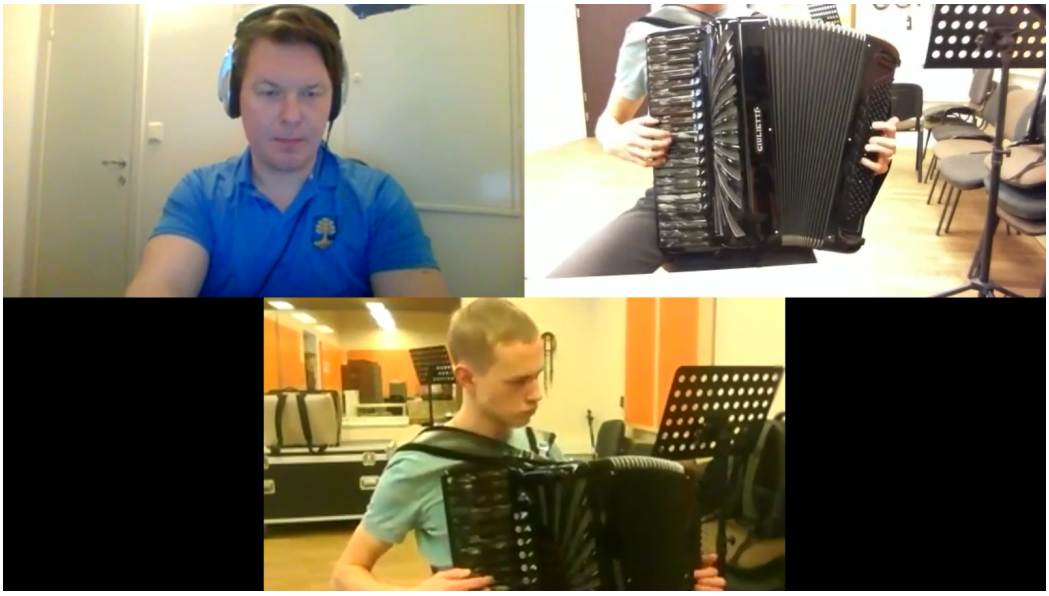
Low latency connections between two or more locations with the aim of making music together is a possibility these days but it can be said based on my February 5th experience at the workplace with LoLa[6] that, as of 2018, setting up and running such videoconferences is still quite resource-heavy in terms of time, people, equipment and network bandwidth required. As time and innovations will lower the threshold to engage in low (or no) latency connections, I see

[6] lola.conts.it

no reason why they would not be an affordable and manageable option also for remote music lessons.

Student playing, teacher watching

At the outset, it was agreed that we would try and find a setup that is (among other qualities) mobile, meaning not tied to a specific location and thus offering both the teacher and student the freedom and flexibility in agreeing a time and place for their lessons. This approach implies that participants could use their own computers and, ideally, would not have to buy new ones. However, web cameras integrated to laptops or tablets, especially to older ones, tend to mediate only a restricted field of view (e.g. 'talking head') at relatively low video resolution (e.g. 480p or 720p). The former especially had caused some camera management for the student in remote lessons where only his computer's integrated camera would be available. He could either show himself as a talking head with the top of his accordion also visible, or, when the teacher wanted to follow the whole instrument, the student had to adjust the laptop's lid to crop his face out of the video feed. To me, the student having to adjust the camera is a distraction I could help him get rid of. Camera management at the student end is an example of systemic variety similar to where he was busy managing the headphones (discussed earlier in this section). In my opinion, without such things to manage, the student has more freedom and can focus better in remote lessons.



February 2nd. Examples of what integrated web cameras can mediate. Clockwise from top left corner: teacher laptop, school laptop, student laptop (screenshot from the Zoom recording).

As for the receiving end, that is the teacher watching how the student is playing, the teacher had after a few lessons (e.g. February 2nd and April 6th) suggested it would be nice if, going forward, he received two video feeds, one with the student and the other with the keys (the hands). In our post-lesson discussion on April 6th the student supported the teacher's idea, confirming it was somewhat weird to keep managing his camera feed (and to be present in lessons with his head hidden). I promised to them a step forward for the next session which would be in a week. Having done some research on the internet regarding different fields of view in web cameras, what I decided to buy for the school and take to the April 13th lesson was an external 1080p resolution web camera with a wide, 90-degree field of view and autofocus. The idea was to check if, for the teacher, that one alone would do the job of two mid-range web cameras with a narrower field of view.

April 13th. The Logitech c930e web camera connected to the student laptop, providing a 90-degree field of view (screenshot from the Zoom recording).

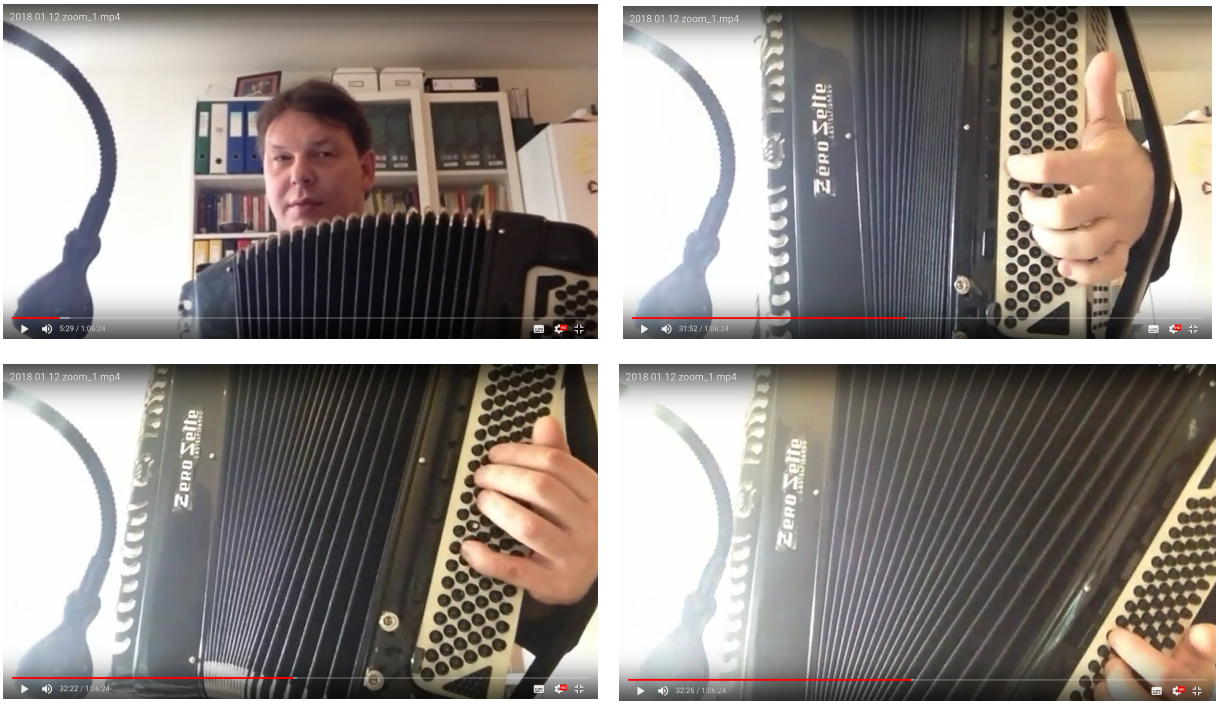
The teacher's feedback after the lesson was positive. He said he was able to see the student and the whole instrument in one frame, confirming the investment in the new camera (*circa* €130) had been worthwhile. However, he said he would also like to remotely zoom in to get a closer visual on the student's hands. The main reason for this is that all keys on the student's accordion are black, as opposed to the teacher's black and white keys, providing more

contrast. In a post-lesson discussion between the teacher, student and myself we agreed that an immediate remedy for the challenge would be to place the camera closer to the student or have the student move closer to the camera. However, the latter would also mean moving closer to the microphone, potentially causing distorted sound sent to the teacher. This goes to show that it is all about balancing the positioning of different equipment and keeping the other participant informed of changes perceived at either end of the videoconference.

However, the amount of such organising communication can be reduced to have more teaching and learning done in a lesson. As for the teacher's request to be able to zoom in to the student's playing, I found for him a solution that would be less disturbing for the learner. In the Zoom videoconferencing service, which, starting from April, is both the student's and teacher's choice of VC service thanks to its sound and image quality as well as stability, the user can allow another user to take control of his/her camera during a meeting. Having tested this functionality on May 22nd with the supervisor of this thesis I can confirm that all it takes is a web camera capable of pan, tilt and zoom functionality, just like the one I purchased for the school before the April 13th session. Hence, I adjusted to what the teacher needed and added the ability to zoom in to his arsenal for future remote lessons.

Teacher playing, student watching

Similar to the student, when working with an integrated web camera (either in his laptop or iPad) the teacher was able to produce only a limited field of screen view. In his May 6th interview to me, when looking back at the seven-month exploration, the teacher said he had not really been paying attention to how his picture has come across and that the student had not brought it up with him either. This is where the teacher seems to have been a bit too critical of himself since an example from the January 12th lesson (which I spotted when reviewing the recordings) demonstrates that he is quite aware of the limited field of view of his camera. At least for an accordion. He stands up to demonstrate for the student a certain left hand technique. However, as he expands the accordion his left hand gets almost out of frame. He was limited by technology available to him.



January 12th. iPad's camera at the teacher end. His left hand moving out of frame due to camera's narrow field of view (screenshots from the Zoom recording).

The student did not bring up the limited field of view in the teacher camera after the January 12th lesson. However, in the final interview, when looking back to the seven months, he said that in the future he would definitely prefer a wider field of view and a sharper picture to come through from the teacher end. He needs to see the whole instrument when the teacher is playing. This student feedback as well as my observations confirm the need for the teacher to deploy a better web camera. Preferably as good as the one the student end is successfully deploying since April 13th. This suggestion has been forwarded to the teacher.

Regarding internet connection

Last but not least, successful videoconferencing requires reliable and high-bandwidth internet connection available to all participants. I learned from the student that back in September, before he came to me, he and the teacher even had to quit one lesson due to poor wireless internet signal at the school. Since the October 4th lesson, the first I was involved in, I've made wired internet connection available to the student at the school for remote lessons. During the seven months, I noticed no internet connection problems at the teacher end of operations.

Main findings from managing videoconferencing

Table 2 gives an overview of the main developments during the 11 sessions, also indicating which videoconferencing (VC) service was used at the time. ‘Ha’ stands for Google Hangouts, ‘Le’ for Lesono, ‘Zo’ for Zoom and Zo* for Zoom with Original Sound preserved. Table 3 below provides a summary of the main challenges and action carried out, which lead to the main developments.

Table 2. Main developments pinpointed.

Lesson, VC / Action domain	4.10 Ha	3.11 Le	17.11 Le	12.1 Zo	26.1 Zo	2.2 Zo	9.3 Ha	21.3 Le	31.3 Le	6.4 Zo*	13.4 Zo*
Internet connection	**#0**										
Audio related						**#1**		**#2**	**#3**	**#4**	**#6**
Video related											**#5**

Table 3. Main challenges and developments described.

Challenge	**Action**	**Videoconferencing domain(s) addressed**	**Action date**
School wifi not reliable, student and teacher had to quit one of the lessons in September. Serious lesson downtime.	**#0** Student end provided with a reliable internet connection (wired LAN).	ALL	4 Oct
Poor audio coming through from the teacher.	**#1** Teacher end successfully pilots and starts using an external audio interface and microphone.	Teacher playing, student listening	2 Feb
A complex and unpredictable sound card causing instability at the	**#2** Student end successfully pilots a simple and stable external audio interface.	Student playing, teacher listening	21 March

student end and lesson downtime.			
Connecting an audio interface (sound card) and microphone to his computer has not always yielded a stable setup at the student end. Potentially causes lesson downtime, stress and ICT related frustration.	**#3** Student end successfully pilots and starts using a USB microphone, bypassing the need for an external audio interface and microphone.	Student playing, teacher listening	31 March
Criticism from the student since January about the quality of incoming audio.	**#4** Teacher and student ends successfully pilot and start using the Original Sound and Stereo mode on the Zoom videoconferencing service.	Teacher playing, student listening; Student playing, teacher listening	6 April
A suggestion from the teacher to have two video feeds from the student end.	**#5** The student end successfully pilots and starts using an external web camera with 1080p resolution, 90-degree field of view and autofocus.	Student playing, teacher watching	13 April
Headphones needed when echo-cancellation is turned off, but headphones limit the student from listening to all the nuances in his playing.	**#6** The student end successfully pilots headphones-free monitoring of incoming audio.	Teacher playing or talking; Student listening; Teacher and student conversing	13 April

Discussion

Results in the light of theory on managing variety

In this section I will revisit the main findings presented in the previous chapter through the lens of the VSM and variety handling strategies. Thereby I can exemplify and explain *how* an educational technologist *is* engaged with managing variety.

The first finding to be presented is simple yet of crucial importance. As in the VSM, where massive flows of information within the system and between the system and its environment are a prime characteristic of viability, in videoconferencing you cannot function without a stable high-bandwidth internet connection. By supplying the student with a reliable and high-bandwidth wired internet connection at the school, I attenuated for him variety coming from system ‘VC’. The variety caused by the lack of a reliable connection component had, in September, caused in system ‘Lesson’ poor experiences and even lesson downtime. Keeping track of the internet connection parametres at both ends in all 11 remote lessons under investigation in this study, in variety-engineering terms, was monitoring certain ‘essential variables’ (Ashby, 1960, p. 42) in system ‘VC’, closely related to its existence.

Another aspect refers back to Ashby’s Law (1957) (see pages 8 for a definition). In the context of this case study it means that, for system ‘Lesson’ to control system ‘VC’, ‘Lesson’ must be able to generate at least as much variety as ‘VC’. However, the 18-in-channel audio interface we had used from November to the end of January, as part of ‘VC’, generated so much variety—expected as well as unexpected—that matching it by system ‘Lesson’ variety would have meant having the sound engineer present at the start of and on standby during all the remote lessons. On the one hand, this would not have been possible due to other work commitments around the school, while on the other hand, such dependence would not contribute to encouraging self-sufficiency of operations, including networked lessons. By successfully introducing a simple and stable external audio interface, I attenuated systemic variety for the student. As a result, going forward, he had less technology to manage and worry about.

I further attenuated systemic variety for the student by replacing two devices (audio interface and a microphone) in system ‘VC’ by just one—USB microphone. In addition to significantly increasing the student´s self-sufficiency, this move, including a quick consultation from the sound engineer, also made mobility possible. By providing the student with tools and

knowhow on sending high-quality audio to videoconferencing from any place (with reliable internet), I also amplified his regulatory variety. In effect, he will be able to absorb greater variety in similar educational, professional or personal contexts.

However, the variety handling act that probably had the biggest effect on system ‘Lesson’ as a whole was finding, testing and introducing Original Sound mode on the Zoom videoconferencing service. By discovering the Original Sound option I was able to attenuate systemic variety for both the teacher and the student. This enabled me to adjust system ‘VC’ so that it was finally able to mediate sound that both parties within system ‘Lesson’ were content with.

Interestingly, this attenuation and increase in quality created a new round of systemic variety to handle. Since echo-cancellation is part of the all-or-nothing package of audio enhancements disabled by and for the Original Sound mode, ideally, both parties have to wear headphones to isolate incoming audio from looping back to its sender when using this option. While the teacher had worn headphones in lessons since February, it is not a practice desired by the student. Basically, this is a rather complex case of where system ‘VC’, having concurrently obtained new values in several areas (audio enhancements and managing listening), revealed that one of those new values (the need to use headphones) is undesired by system ‘Lesson’. Adjusting to the student’s (one of the two regulator’s) needs, I set out to find out with the group if we could balance these varieties.

Having found a solution to headphones-free monitoring at the student end, I was able to significantly increase the quality of the teaching and learning experience in system ‘Lesson’ by attenuating systemic variety both for the student and the teacher. What this yielded is that, going forward, the student did not have to manage headphones when in a remote lesson, and could thus focus better. For the teacher the communication channel was reopened so he could play or talk to the student any time during the lesson. It was critical for this balancing act to be successful. Otherwise we would have faced a choice between two scenarios decreasing lesson quality—either the student is restrained from listening to all the nuances in his playing (with headphones on) or we turn off the music-friendly mode on Zoom (and keep looking for a more suitable videoconferencing service).

Introducing a wide field-of-view web camera further attenuated systemic variety for the student. Although quite simple at first sight, this particular balancing act is an example of what could be referred to as variety ‘juggling’. I helped the teacher successfully regulate certain

variables in the system, but not by exactly following his suggestion (two camera feeds). By not employing two camera feeds, I was protecting the student (and myself) from collateral systemic variety. Based on what I had seen and experienced in videoconferencing by then, I could see that setting up and producing two camera feeds could have been too demanding and distracting for the student to manage. Furthermore, making sure the two camera feeds from one location are absolutely synchronous, could have added even more variety to handle. The low-maintenance (yet high-quality) solution provided a satisfactory view for the teacher, and concurrently the quality of remote lessons also increased for the student. He did not have to adjust the camera or think about it when playing the instrument.

What can we take on board from these variety handlings?

First of all, when you reduce systemic variety, you refrain as much as possible from compromising the quality of operations. What I am trying to convey here was well put by the student in his final interview to me. In a nutshell, we characterised our endeavour as 'finding the optimal ratio of quality to ease of use.' I find his phrasing of the regulatory equation to be a telling measure of variety handling success. In the end, what matters is what the teacher and the student are getting as a result of the variety balance (or unbalance) in place at a certain point in time. Impact is exactly what brings to fore the insight that placing a new device or method in the 'equation', alone, is *not* variety handled and done with. The new tool is merely a carrier of change as tools that help provide higher quality of operations are likely to entail some work to be done as to the users' proficiency with them. In a contrasting scenario, if an overly simple and easy to use tool is introduced, the quality of operations might be compromised to some degree.

Having alluded to quality management, I would like to outline two important dimensions in the world of a variety handler—assessment and monitoring. In order to do a good job, first, a variety handler should assess, on the one hand, what the operations want to do or achieve *versus* the knowledge and skills they have available relating to the tools (potentially) involved. Ideally, these assessments are done *before* a new tool is and introduced. Secondly, once a tool is 'installed', I would expect a variety handler to monitor the outcomes in order to evaluate the impact of his or her contribution. In the monitoring dimension of the balancing we have, on the one side, the quality of the actual experience where a tool was involved, and on the other, the actual level of mastery in putting a tool to good use.

The key of achieving this is listening to ‘your’ teachers and students to understand what they need. You balance varieties where needed. You attenuate or amplify on the right ‘pole’ of the equation, or mix the two strategies. Then you monitor varieties by again listening to your teachers and students. Where balance is good, you maintain it, for example, by having brief discussion with them every now and then, before or after class. When all these areas are covered, we can refer to a juggler, who is balancing variety ‘supplies’ between the tools and the educators and learners.

As a further development, adding the dimensions of assessment and monitoring onto the balancing ‘equation’ used in the context of this case study, I will explain how the following visualisation (see figure 5) could work as a variety handler’s ‘compass’ in pursuit of viability.

The red ‘needle’ stands for assessment. Here, the Northwest end of the ‘needle’ has to do with assessing whether a tool is proportional to teaching and learning needs—what and why is expected from the tool and how much systemic variety it would bring along. The Southeast end of the ‘needle’, however, stands for understanding if the currently available ‘user variety’ is a match or not to the ‘tool variety’. As mentioned before, this should ideally be done before the tool reaches the user.

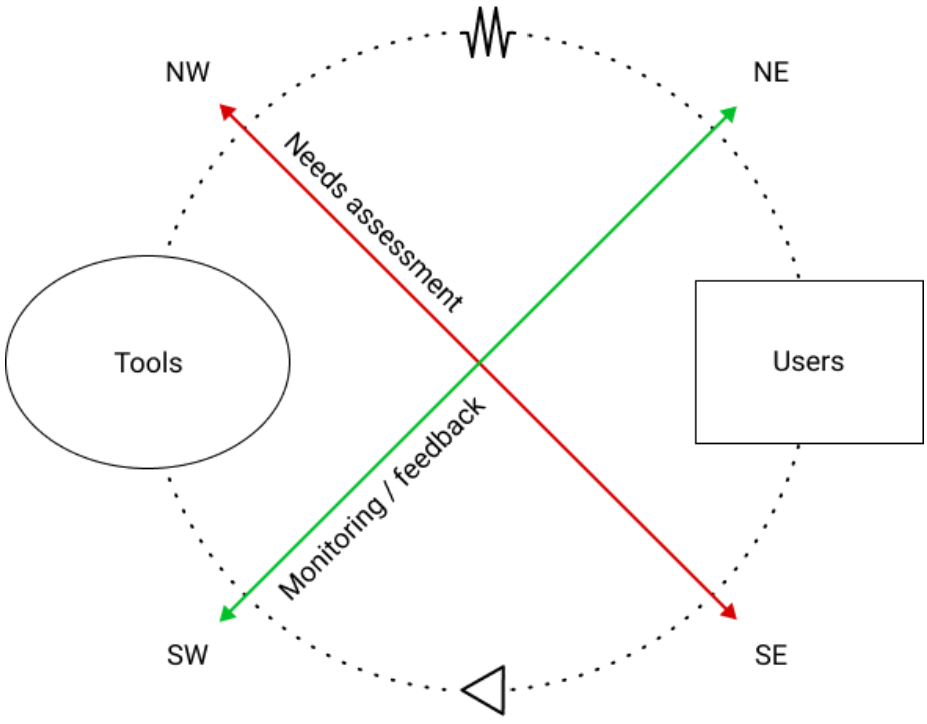


Figure 5. The variety handler’s ‘compass’.

The green ‘needle’ is concerned with monitoring and feedback. The Northeast end of the ‘needle’ indicates monitoring whether the learning and teaching experience is smooth and enjoyable with the tool as it is, while the Southwest end of the ‘needle’ is concerned with whether the teacher and student are *actually* able to operate the tool. Ideally, they would be able to do it effortlessly.

The North and South ‘poles’ are about action corresponding to input gathered from the red and the green ‘needles’. The ‘zigzag’ in the North ‘pole’ stands for reducing the incoming flow from the West (the tool) and making it digestable for the East (user) or proportional to what the user wants to do or achieve. To this end, undertakings would involve technical support, getting to know and testing the tool before it ‘reaches’ the user. The triangle in the South ‘pole’ stands for amplifying, to make sure that the user would not engage with the tool in a state that does not allow him or her operate it properly or proportionally to his/her needs. Activities in the South include consultations, discussions, trainings, and last but not least, actually using the tool. Ideally, these activities are carried out until the user becomes self-sufficient.

The notion of self-sufficiency brings us to what is viable according to Stafford Beer (1985)—capable of independent existence within a supportive environment. The context of this case study, however, calls for a more detailed definition. The green ‘needle’ on the variety handler’s compass will give us the answer. Videoconferencing in one-to-one remote music tuition is viable if, first and foremost, the teacher and the student can do what they need to do, at a quality they are used to, meaning, when lessons can accomplish their purpose. And secondly, if they themselves can use the tool so well that it ultimately fades into the background.

Conclusion

Educational technologists are seen as people designated to helping educators and learner navigate the influx of available tools, services and options therein. Thus, the major challenge that educational technologists face doing this is that of ‘incoming’ variety. In the present thesis I have interpreted the role of an educational technologist as a variety handler in light of the Viable System Model (Beer 1979, 1981, 1985) in order to address the problem of how to help educators and learner manage variety in such a way that technology use enhances and does not hinder their teaching and learning.

To explain and exemplify how an educational technologist is engaged with handling variety, an exploratory case study was conducted on how to facilitate viable videoconferencing in remote music tuition. Analysing real-life examples from the collected data in light of the Viable System Model and variety management strategies allowed me to explain how variety can be handled (and balanced) for the viable system of 'remote lessons', where a teacher and his student are seeking an optimal ratio of quality to ease of use. Discussing highlights from the main challenges (en)countered and real-life variety handled, yielded explanations of the VSM theory through down-to-earth examples.

Interpreting the challenges faced and responses to them in terms of the VSM revealed that from the educational technologist's viewpoint, videoconferencing in one-to-one remote music tuition is *viable* if, first and foremost, the teacher and the student can do what they need to do, at a quality they are used to, meaning, when lessons can accomplish their purpose. Secondly, the teacher and student need to be able to use a tool so well that it ultimately fades into the background. Viability in this context is the result of successfully balancing varieties between users and tools.

The main result from this study is that, in order to achieve such a balance, not only does an educational technologist need to choose the right variety handling strategy, but any attenuation or amplification should ideally be a result of either assessing users' needs and the appropriateness of tools available or monitoring whether the teaching-learning experience is at the desired level of quality and whether teachers and students are able to use tools self-sufficiently. By adding these two dimensions alluding to quality management – assessment and monitoring/feedback – onto the balancing 'equation', I have presented a variety handler's 'compass', pinpointing sectors of recommended activity to achieve or maintain balance, and thereby viability. This tool is applicable in any relationship between two 'systems' (living or artificial).

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I hereby declare that I have written this thesis independently and that all contributions of other authors and supporters have been referenced. The thesis has been written in accordance with the requirements for graduation theses of the Institute of Education of the University of Tartu and is in compliance with good academic practices.

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Appendix 2. Questions in the interim interview

Student interviewed on 2 February, teacher on 3 February, 2018.

1. Please tell me a few keywords that first spring to mind if you think of the experiences, good or bad, with your remote lessons.
2. Our goal is to reach a point where we have a solution that can be set up fast, that is fool-proof and mobile. In your opinion, have we reached that point?
3. Regarding instrument tuition, how do you feel — have our 'labs' (since October 2017) been somewhat hindering or have you been able to proceed full-throttle just like before (when we were not experimenting)?
4. If you take, on one hand, the 'videobridges' as they currently are (in February 2018), and face-to-face lessons on the other — what are the main differences or shortcomings?
5. Perhaps there is something missing regarding the playing technique where the teacher would have to be physically present to demonstrate something?
6. If we could add to videoconferencing the possibility of playing together (in real-time), would it then be like 'the real thing' (face-to-face lessons)?
7. In your context, what would making music (playing) together yield?
8. We are in the middle of our 'journey'. How do you feel, are you now better prepared for ICT challenges?
9. Would you like to add something?

Appendix 3. Questions in the final interview

Student interviewed on 30 April, teacher on 6 May, 2018.

Teacher only*
Student only **

1.1 Your age?
1.2 Your experience, in years, as a student/teacher in music?
1.3 ...out of which with the accordion?
1.4 Your experience, in years, with your current teacher/student?
2. Looking back at the eight months and your work your teacher/student...
2.1 In your opinion, what are the positive aspects of remote music tuition?
2.2 In your opinion, what are the negative aspects of remote music tuition?
2.3 If we look at the last couple of lessons in Zoom with Original Sound and Stereo, how would you describe the sound quality that you have had?
3.0 Please describe the previous experience you have had with remote music tuition.
3.1 Have you had to change you teaching methods for the remote lessons?*
3.2 If yes, in what way?*
3.3 How have you been able to communicate with you teacher/student? Which means of communication have you been able to use?
3.4 Have you been able to perceive the teacher’s instructions clearly? (If yes, 3.5: describe. If no, 3.6: describe.)**
3.7 Have you been able to perceive the music examples from the teacher clearly? (If yes, 3.8: describe. If no, 3.9: describe.)**
3.10 In what way did the communication between you and the teacher/student work?
3.11 What could further enhance the remote lessons?
3.12 Has introducing remote lessons had any positive aspects?

3.13 Has introducing remote lessons had any negative aspects?
3.14 In you opinion, what could be improved with the technology based on the remote lessons you have had with the teacher/student?
3.15 In you opinion, what could be improved in the teaching based on the remote lessons you have had with the teacher/student?
If you keep in mind the last couple of lessons in Zoom with Original Sound and Stereo, then ...
4.1 On the topic of user freedom or flexibility more generally, do you feel in any way limited in remote lessons?
4.1.1 Was it the technology? (ICT tools used)
4.1.2 Is it the distance between you and the teacher/student?
4.1.3 Is it the lack of presence by the teacher/student?
In a way, remote lessons provide freedom… 4.1.4 What is it that makes you feel free in your practice?**
4.2 Can you do the things that you want to do in remote lessons?
4.2.1 Have there been lessons/moments where the sound has been a hindrance?
4.3 In general, have you been able to participate in the remote lessons without being affected by the technology?
4.4 Do you perceive the technology (ICT) as a hindrance or as a tool?
4.5 What has worked and what hasn’t worked during the remote lessons - concerning technology?
4.5 What has worked and what hasn’t worked during the remote lessons - concerning pedagogics/teaching?
Thinking about the last couple of lessons in Zoom, with Original Sound, and USB microphone...
4.7 Could you compare the sound perceived to a known format/media, e.g. from the perspective of a consumer of music?
4.8 How have you perceived the sound and video quality?
4.9 Leaving the video quality aside, how have you perceived the sound quality?

4.10 Leaving the sound quality aside, how have you perceived the video quality?
4.11 Concerning delay/latency. Did you perceive any delay/latency between the sound and video you received? Are the signals that reach you synchronised?
5.1 Please describe in your own words what components constitute successful/sustainable videoconferencing in remote music tuition.
5.2 Thinking about the last couple of lessons in Zoom with Original Sound and the USB microphone, to what extent (on a scale of one to ten if need be) have you been able to ...
5.2.1 play (the instrument)
5.2.2 show
5.2.3 talk, converse
5.2.4 listen
5.2.5 watch
6. Thinking about the last lessons where we had stabilised the situation and found a setup that worked. How would you describe the following categories?
6.1 accessibility (threshold)
6.2 ease of setting up
6.3 ease of use (user-friendly so that teacher/student can stay focused and on task)
6.4 mobility (easy to set up anywhere with sufficient internet connection)
6.5 recordability
6.6 sustainability (any potentially weak links in the ‘chain’?)
7.1 Do you feel you could set up remote lessons like the ones you have had on your own in the future?
7.2 How about autonomy if you compare the situation in September-October to now?
7.3 Would you recommend this kind of solution to your colleagues?
8. Any last comments?
How have the remote lessons with your other, younger student been going?*

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