SINGEWING SPACE

An augmented blended-learning approach
to music learning

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1. INTRODUCTION

Since the start of the digital revolution, our ways of retrieving, processing, and absorbing information are continuously changing due to the easy and ubiquitous access and possibilities to share all sorts of information. The technological transformation in the availability of technological devices has brought online knowledge sharing to the attention of numerous learners and teachers around the globe. Contingent on the rapid expansion of communication technologies, teachers, students, and educational policy advisors reconsidered traditional forms of teaching and learning. The combination of technology and learning, marketed as online learning or e-learning, continues to advance (Moore, 2011). Evidently, the adoption of technology has implications for how we teach and learn: teachers and students no longer solely depend on scheduled classes to share learning content. Instead, they can learn and teach through online platforms such as Khan Academy, Udemy, and Coursera. In this way learners can choose when, where, and at which pace they learn, thus increasing the autonomy of learners (Arkorful & Abaidoo, 2014). Even though there are advantages to online learning, the most noticeable disadvantage of it is the absence of personal interactions, not only between learners and teachers, but also between learners themselves (Arkorful & Abaidoo, 2014). Furthermore, online learning presents challenges to the learning process, because of limited opportunities for transparent interaction and understanding of body language (Anderson, 2004). For instance, in the case of music education face-to-face interaction is necessary to be able to learn to perform together.

A fairly recent strand in education that integrates digital tools for online education with offline or face-to-face education is *blended learning* (Macdonald, 2008; Oliver & Trigwell, 2005; Poon, 2013). Blended learning aims to merge online approaches with classroom activities, thereby maintaining personal interactions, but at the same time catering to the various learning strategies of students. As it has become more common through concepts such as "Flipping the classroom" (Foertsch, Moses, Strikwerda & Litzkow, 2002), researchers have shown a growing interest in blended learning (Garrison & Kanuka, 2004; Graham, 2006; Hua, 2013). Research studies have shown that blended learning contributes to a meaningful learning environment, increases the student's involvement in learning processes and, in some cases, increases the learning outcomes of students (Garrison & Kanuka, 2004; Graham, 2004; Macdonald, 2008). In general, teachers too, are convinced of the positive impact of technology on teaching and learning (Bos, 2016; Voogt, Sligte, Van den Beemt, Van Braak & Aesaert, 2016).

Other research studies have voiced a more critical sound and have emphasised that, in comparison to face-to-face learning, neither blended learning nor complete online learning have a significant positive effect on learning outcomes (Bos, 2016; OECD, 2015; Spanjers, Könings, Leppink & Van Merriënboer, 2014). Spanjers, Könings, Leppink, Verstegen, De Jong, Czabanowska, and Van Merriënboer (2015) note that whether or not technology actually impacts positively on education, strongly depends on the quality and relationship between the online and offline learning activities, the interaction with the teacher, the clarity of the instructions, and how challenging the learning environment is.

Even though blended learning by now has taken flight at all levels of education, its online component is still mostly used in traditional ways: sitting behind the computer and interacting with online content using the mouse and a keyboard. However, computers and the way we interact with them have undergone substantial changes, not in the least through the emergence of technologies that enable radically different forms of interaction with them (Price, Roussos, Falcão & Sheridan, 2009). New technologies provide opportunities for learning to be more active and hands-on (e.g. through touchpad, Wii®, Kinect®), and sensor-based technologies are being used to link physical activity to conceptual ideas, through connecting physical activity to audio and visual representations (Price et al., 2009). Current technologies also give access to new forms of communication and collaboration thus promoting socially mediated learning (Dourish, 2004; Price et al., 2009). The strength of these developments lies in the fact that the human-computer interaction is becoming more "embodied" and more natural (Nijs & De Baets, 2015).

To develop a blended-learning environment that incorporates the aforementioned technological innovations, music education provides an interesting case due to its intrinsic features. Learning and teaching in music is a practice in which the social, the physical, and the cultural coincide (Bremmer, 2015; Van den Dool, 2018). Within music education, activities can be described as embodied interactions with music in which experiences are physically exchanged, coordinated, and shaped between learners and teacher. For example, in joint musical activities rhythm, pulse, and timing are co-constituted, co-regulated, and physically felt in the interaction (Bremmer, 2015). It is this multimodal way of learning that challenges designers of blended-learning environments to rethink how and which technologies should be incorporated to establish an added value to musical learning processes (Leman & Nijs, 2017). Yet, different from language, maths, and science education, blended learning within music education is still in its infancy and the effects of blended learning within these fields remain novel and largely unexplored.

The presented project aimed at developing a web-based interactive application that implements an embodied and collaborative approach to music learning. In that sense, our research group wanted to adopt an approach that is inspired by technology (e.g. the possibility of different sensors, online shared environments) but driven by pedagogical and musicological considerations (see also: OECD, 2010). The envisioned application, Singewing Space, is meant to be used in and beyond the classroom, connecting face-to-face learning to online learning. The word *Singewing* means "sense making" in Afrikaans (South-Africa) and the name *Singewing Space* refers to the idea that students meet in a shared virtual space where they learn to make sense of music together in a multimodal way. Using motion capturing and sound recording, this educational technology integrates the possibility to play, sing, and move to music jointly with peers. It enables them to collaboratively create a visualisation of music or movement and to respond to each other's creations through musical and physical actions. As such, the body and social interaction form the heart of Singewing Space.

In this publication, we explain the theoretical background that underpinned the development of Singewing Space, including augmented blended learning, embodied music learning and participatory sense-making. Next, Singewing Space's original concept and the development of the demonstrator are described. Then, we illustrate how Singewing Space can be integrated into general classroom music education. This publication will conclude with a discussion on the development of Singewing Space.

“An *augmented* blended-learning approach is key to bringing online learning in music education to a next level.”

2 THEORETICAL BACKGROUND OF SINGEWING SPACE

2.1. AUGMENTED BLENDED LEARNING

In the past decades educational institutes have advanced rapidly into the 21st century, driven by virtually unlimited technological possibilities catering to educational settings. Ever since, teachers and policymakers have been exploring the use of digital tools within traditional education (Moskal, 2013). As mentioned in the introduction, blended learning is one of the ways technology is being integrated into education through merging online learning approaches with classroom activities. As blended learning is more commonly used in the fields of language, maths, and science education, to date, little is known about its use in music education. One of the few studies on the use of blended music learning has been conducted by Van den Dool and Van Baalen (2017) in higher music education. The authors found that three themes emerged regarding the effective use of blended learning in higher music education that could also be applicable to general music education.

FLEXIBILISATION OF EDUCATION

The traditional face-to-face approach to education has many advantages, but it often leads to rather fixed educational settings and organisation. In the case of instrumental and vocal music education as well as general classroom music education, pupils usually get one lesson per week. In-between lessons, they have to learn music without additional support from a teacher or peers.

Blended learning separates time from space and offers the freedom to learn anytime, anywhere (Crawford, 2016). In this way it offers ample possibilities for the flexibilisation of education (CBL, n.d.). Furthermore, in this way it may enrich classroom activities with additional support during the week.

MOTIVATION AND ENGAGEMENT

Motivation and engagement are essential factors of the learning process. The more learners are motivated, the more they will be engaged with learning activities through sustained interaction and practice. An effective way to stimulate motivation is to invite students to actively participate (Svanum & Bigatti, 2009).

Blended learning extends engagement beyond the classroom and can motivate the learners to actively participate in online discussion, musical games, and online exercises. Next to providing learners with rich musical experiences and participation, blended learning may also provide learning content that is tailored to the individual musical needs of a learner, thereby supporting self-regulation and self-efficacy, which are important elements of motivation and engagement (Cogdill, 2014).

FEEDBACK

Feedback is an essential aspect of learning that can play both an informative and a motivational role (Tricomi & De Pasque, 2016). It not only contributes to specific aspects of the learning process, such as self-regulation and self-efficacy (Puustinen & Pulkkinen, 2001) but it also plays an essential role in establishing an optimal learning experience (Csickszentmihalyi,1990).

Blended learning offers new possibilities to provide students with feedback. The online component can be used to gather information on the learning process (learning analytics)

(Chen, Breslow & De Boer, 2017). This information can be used as immediate and adaptive feedback on task execution, but also to stimulate metacognitive skills and learning strategies (Hattie & Timperley, 2007). Furthermore, the online component of blended learning can integrate peer assessment via open-ended learning environments that support constructivist learning (Steels, 2015). Finally in addition to the prevailing verbal and written feedback, blended learning can introduce new forms of feedback, based on the visualisation of performance (Nijs & Leman, 2014, 2016).

In addition to these three themes, we propose to take an augmented approach to blended music education because of pedagogical advantages for learning music.

AN AUGMENTED APPROACH TO BLENDED LEARNING

Augmented blended learning can complement traditional ways of online learning by introducing different sensors such as Mogees® and Leapmotion® in the interaction with the computer. Such sensors enable bringing the *bodily* dimension of musical interaction (e.g. entrainment; see Leman, 2016) into play, and could have the ability to facilitate embodied music learning and participatory sense-making in the virtual environment of Singewing Space. The theory of embodied music learning and participatory sense-making will be discussed in the section below.

2.2. EMBODIED MUSIC LEARNING

From birth, learning occurs through our sensory engagement with the world (Hannaford, 1995; Schroeder, Wilson, Radman, Scharfman & Lakatos, 2010). The primacy of movement, and thereby of the kinaesthetic sense, is reflected in the inability to shut off our kinaesthetic feelings like one can shut off vision by closing the eyes, noise by clamping the ears, or smells by pinching the nose (Sheets-Johnstone, 2011). As such, movement and bodily awareness are both fundamental to our interaction with the world and to learning (Gallagher, 2017; Piaget, 1964; Vygotsky, 1978). This vital role of the body in our understanding of the world is the basic idea of embodied cognition, and according to this view, cognition is shaped through a dynamic interplay between body, brain, and environment (Anderson, 2003). The theory of embodied *music* cognition builds on that idea by stating that one's understanding of music occurs through an active bodily involvement with music (Leman, 2007, 2016). This theory proposes that when we interact with music through listening, dancing, or playing, a connection is made between sound, movement, and intention. This connection can come into existence as music and movement share certain features (Sievers, Polansky, Casey & Wheatley, 2013). Both music and movement are time-based, imbued with a specific quality and both give a sense of an intentional direction that can elicit an emotion such as happiness or sadness (Stern, 2010). From this perspective, making sense of music can be understood as a multimodal learning process (Nijs & Bremmer, forthcoming).

The music-movement-intention connection enables a transformation process, also called *enactment*, that turns a seemingly random stream of sounds into a meaningful musical experience. Such transformation is based on the association of patterns in the sounds (e.g. chord sequence or melody) with movement patterns (e.g. shape, direction, energy) and thereby with the intentional states (e.g. an emotion) that underlie these patterns. The general processes of attributing intentions to music by associating musical and movement patterns, is rooted in several basic mechanisms, namely alignment, entrainment, and prediction.

ALIGNMENT

When moving to music, most of the time people try to attune or align their physical actions in response to specific musical elements such as the beat or the loudness (Eerola, Luck & Thompson, 2009). Leman (2016) distinguishes between two main types of alignment to music. The first type, "phase alignment", describes the synchronisation of movements to prominent time markers in music, for example shaking the head to the beat. The second type, "inter-phase alignment", describes the matching of the continuous expressive flow of physical actions to the time in-between the beats of the music, for example mimicking the melodic contour by moving the hand up and down. Simply said, phase and inter-phase alignment describe how physical actions match what happens in the music, i.e. on the beat and in-between the beats. Both types of alignment to music are not only means to express how we feel the music but they are also essential in understanding the music.

ENTRAINMENT

The ability to synchronise with someone or something is a natural human response. For instance, when walking together with a friend you will find that at a certain point your footsteps will unconsciously start synchronising (Bennet, 2002). This natural process of being *pulled* towards synchronisation is also called entrainment. The concept of entrainment can be described as "the coordination of temporally structured events through interaction" and helps one to align with music (Clayton, Sager & Will, 2004). By pulling people towards the beat of the music, the process of entrainment helps people to find, keep, and become the beat. *Finding* the beat occurs through recognising the regularity in the salient markers in music, which in turn allows for *keeping* the beat, and eventually for becoming the beat. This process of finding, keeping, and being the beat in turn enables the emergence of a person's overall timing framework (phase alignment).

Interestingly, when interacting together with music, social entrainment may emerge: people might detect rhythmical signals through auditory (playing, singing) or visual (playing, singing, dancing) cues coming from the others and adjust their own responses to those signals (Phillips-Silver, Aktipis & Bryant, 2010). If this process occurs accurately, a congruency emerges between different people's responses and the music. Social entrainment can be mutual, i.e. between two people such as turn taking in a conversation, or collective, i.e. happening in a larger group.

PREDICTION

Alignment and entrainment are closely connected to a third basic mechanism, namely prediction. This involves the ability to sense or anticipate how the music will unfold and to predict the outcome of a movement, such as hitting a drum, or predicting how the end of a movement coincides with the beat. A wonderful example is shown by Bobby McFerrin at the World Science Festival, using movement to make the public sing the next note in a pentatonic scale *(link: https://www.youtube.com/watch?v=ne6tB2KiZuk)*.

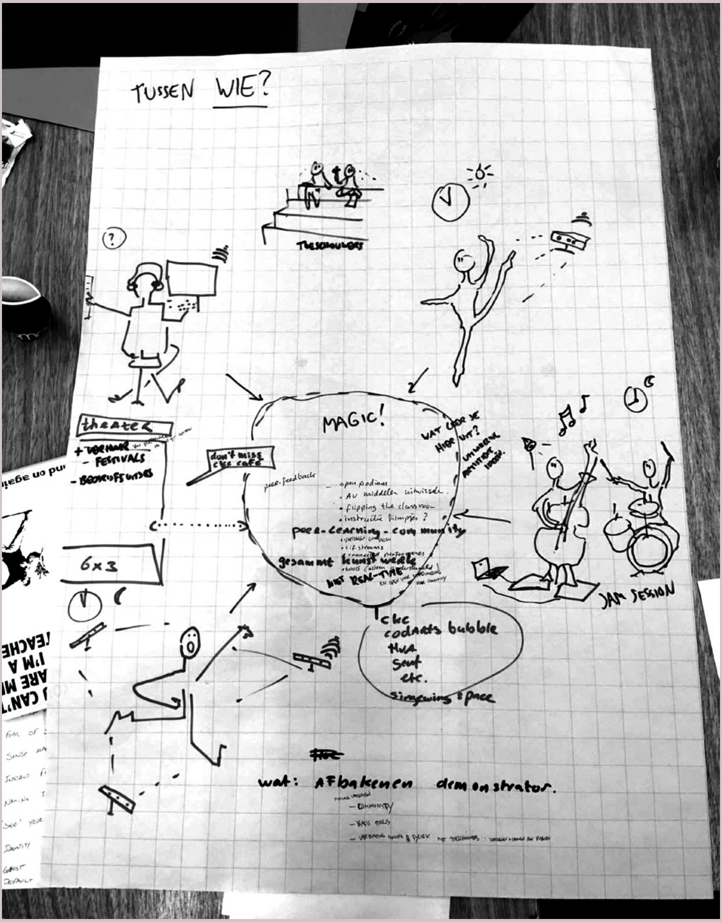
An embodied-cognition approach assumes that, together with the biomechanical constraints of the body (such as the length and form of our legs and arms; e.g. Dahl & Huron, 2007), different states of arousal such as feeling fatigued or being energetic, characterise the way in which we interact with music. From this perspective, prediction of music is viewed as the expected outcome of *bodily-mediated* perceptions and physical actions with music, rather than the expected outcome of a direct line between music and the brain.

TIMING STRATEGIES

Timing is an important element of musical expressiveness, not only in playing an instrument but also in generating bodily responses to music, such as in dancing or stepping to the music. Indeed, both playing and moving to music require the controlled and precise execution of movements. Developing timing skills is, therefore, essential in the music learning process. Timing skills rely on different innate human timing strategies. One such strategy, *event-based timing*, involves a clock-like neural process that internally keeps time by determining significant events in time (Zelaznik, Spencer & Ivry, 2002). Event-based timing has been linked to discrete movements, i.e. movements with a definite beginning and endpoint, such as clapping to the beat. Another strategy, *emergent timing*, involves the dynamic sensorimotor processes underlying an ongoing movement (Zelaznik, Spencer & Ivry, 2002). Emergent timing has been linked to *continuous* movements, i.e. movement without a distinctive beginning and endpoint, such as showing a phrase with one hand (Huys, Studenka, Rheaume, Zelaznik & Jirsa, 2008; Torre & Balasubramaniam, 2009). However, timed actions as in playing music or moving to the music may rely on a combination of event-based and emergent timing and their associate movements. Although training both mechanisms and strategies is therefore important in the music learning process, research indicates that music education mainly focuses on event-based timing (Janzen, Thompson & Ranvaud, 2014).

2.3. Participatory sense-making

De Jaegher and Di Paolo (2007) coined the term "participatory sense-making" to describe how meaning is generated and transformed in the interplay between the process of interaction and the person's engagement in it. Therefore, making sense of music could be described as a "participatory sense-making" process because social dynamics such as physical coordination, gestures, facial expressions, and interaction all affect individual sense-making of music (Schiavio & De Jaegher, 2017) and can generate novel ways of sense-making that were not available to individuals on their own (De Jaegher & Di Paolo, 2007). Learners can also make sense of music by talking about and reflecting on it in a social context. As learners can make complimentary, contrasting, or unexpected reflections, their shared understanding can grow in an emergent manner that would be more multifaceted than what each pupil would be able to achieve individually (Davis, Hsiao, Singh, Li & Magerko, 2016). Participatory sense-making thus could be given a central role in music learning, whether in the classroom or online.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"The body and social interaction form the heart of Singewing Space."

3 THE CONCEPT AND DEVELOPMENT OF SINGEWING SPACE

3.1 INITIAL CONCEPT

The concept of the educational technology Singewing Space originated from another educational technology, the Music Paint Machine (MPM). This interactive system was designed and developed in a pedagogy-driven way and evaluated based on a user study and a longitudinal classroom study by Nijs (Nijs et al., 2012; Nijs & Leman, 2014). The MPM invites learners to create a digital "painting" by combining music and movement. It has several modes of use, ranging from free exploration to direct instruction. Consequently, learners are stimulated to explore relationships between music, movement, and visuals, and to experiment with and reflect on these relationships. In this way, this interactive music system introduced a novel approach to the use of movement (active vs. monitoring) and visualisation (creative vs. monitoring) in instrumental music learning (Nijs & Leman, 2016). The concept of Singewing Space elaborates on the MPM's idea of combining sound and movement to create visualisations but takes the concept of the MPM a step further by introducing several extensions *(See Figure 1)* and by further elaborating the pedagogical use of the system.

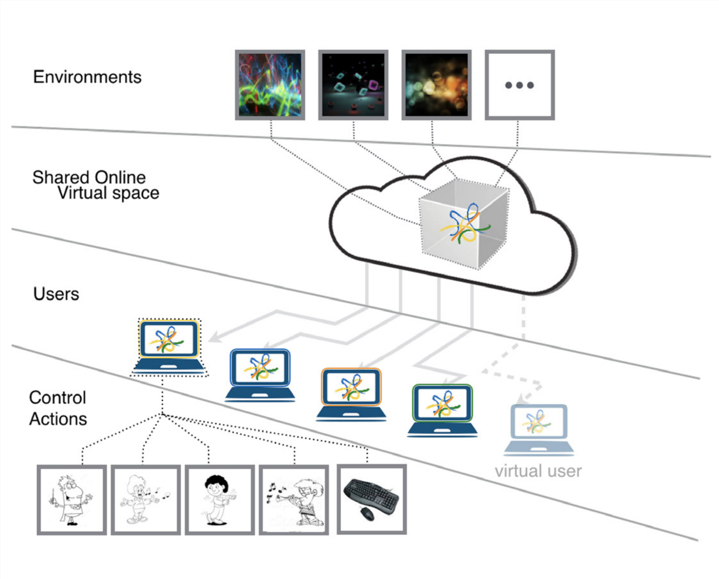


FIGURE 1: Overview of the system, which allows multiple users to create music- and movement-based visualisations in a shared Online Virtual Space by using different control actions. The shared online virtual space can be shaped in different ways by the use of Environments that introduce specific looks and objects.

VIRTUAL LEARNING ENVIRONMENT

Singewing Space wants to extend the implementation of visuals from a 2D projection on one screen to a 3D visualisation in an online virtual space. This virtual space can take on different forms through the use of “Environments” that define the looks of the space and the objects in it, and the control actions based on music and movement. For example, in one Environment, music and movement are translated into lines, while in another Environment music and movement are used to manipulate 3D objects such as spheres, cones, or cubes.

The possibility to choose different Environments allows the *differentiation* between skill levels (e.g. by adapting to a learner’s pitch range, amplitude range, rhythmic abilities) and promotes student *autonomy* and *ownership* (e.g. by allowing learners to create or upload their own objects and sounds). Furthermore, these environments allow for connecting to real-life classroom situations. Figure 2 shows an example of how the typical way of executing musical classroom activities in a circle can be evoked in a virtual environment. Each object represents a user who is interacting with the system and other participants.

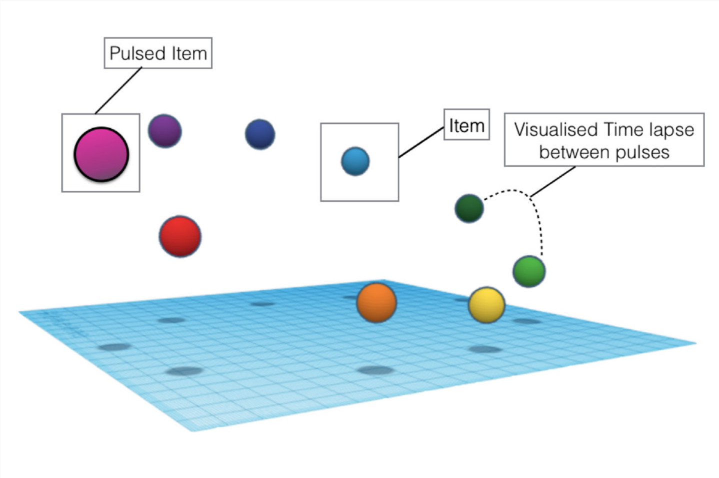


FIGURE 2: Example of an environment in which the objects in a circle represent learners in a classroom.

MULTIPLE USERS

In contrast to the MPM in which only one user could directly engage with the system, Singewing Space allows different users to individually engage with the system and contribute to the joint creation of a visualisation of music and movements. Joint engagement can be online (doing everything together in real-time) or offline (post-hoc adaptations of an online creation). In addition to the actual users, a virtual user can be activated to influence interactions. This virtual user can represent a teacher and scaffold learning by inviting students to certain interactions. Users will be enabled to create a profile, which can be linked to different social networks (e.g. Instagram, Facebook, Youtube).

MULTIPLE MODES OF CONTROL

Another extension concerns the mode of control, i.e. the actions to control the system and to engage in the interaction between music, movement, and visuals. While the MPM was focused on instrumental music learning, Singewing Space allows different forms of learning music by integrating multiple modes of control, including music playing but also singing, conducting (hands), and dancing (whole body). Evidently, interaction through a keyboard is also possible. These modes of control are also connected to the modes of use, which are explained in the next section. To enable multiple modes of control, the system will provide the possibility to use different kinds of sensors, such as Kinect®, Leapmotion®, Myo®, or Makey Makey®.

MULTIPLE MODES OF ONLINE LEARNING

The global framework encompasses two forms of collaborative online learning. Each form of online learning has two modes of use (see next section). A first form of online learning is called *augmented online learning*. Here the traditional human-computer interaction based on mouse and keyboard and attachment to the screen is *replaced* by a mode of human-computer interaction that involves different types of body movement. This mode of human-computer interaction is implemented in two modes of interaction: create and respond. A second form of online learning is the more *traditional online learning*: sitting at the computer. Again two modes of interaction are implemented: alter and reflect.

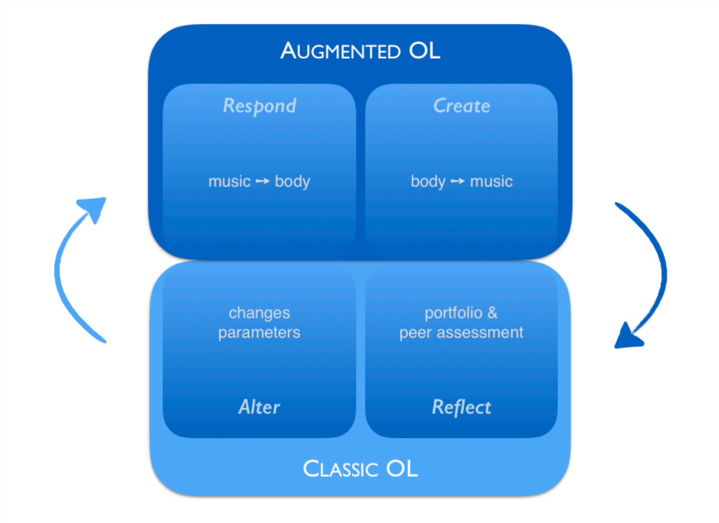


FIGURE 3: Different modes of use as associated to the different modes of online learning

MULTIPLE MODES OF INTERACTION

Singewing Space allows for different modes of interaction in order to stimulate learning in different ways:

- Create
- Respond
- Alter
- Reflect

Importantly, each mode can be used individually or together with others (e.g. peers, teacher, parent), and with or without a "dummy user" (a virtual user who can play the role of a teacher in order to scaffold certain actions within each mode as shown in Figure 3).

Create

In this mode of interaction, users jointly create a visualisation through music and movement. Based on the different control actions, sound and/or movement are transformed into visuals that are displayed in the online virtual space. This can be with or without interaction between different visualisations. The former implies mutual influence/interference between the different visualisations (e.g. collision), the latter implies the mere visualisation next to one another. The visuals can be changed by choosing a different environment. For example, one environment can use lines, another can use 3D geometric shapes.

Respond

In this mode of interaction, users respond to the musical stimuli with body movement. Responses can be generated with body parts (head or hand) or with the whole body. Depending on the action, different sensors are used. Bodily responses of the different users are mapped to visuals that are displayed in the shared online virtual space. This can be done with or without interaction between the visuals. The former implies mutual influence/interference between the different visualisations (e.g. collision), the latter implies the visualisation merely next to one another. The visuals can be changed by choosing a different environment. For example, one environment can use lines; another can use 3D geometric shapes. Musical stimuli in this mode can be rhythmical/tonal patterns (in different tempi) and different genres/style of music. It can be existing recordings, other learner/teacher-generated music.

Alter

In this mode of interaction, users are enabled to work with the creative outcomes that where generated in the first or second mode. The outcomes of mode 1 and/or 2 are stored as a log file that can be replayed. As such, they function as templates that can be altered by changing certain values (pitch, loudness, colours, shapes) or "teleported" into another environment (e.g. from lines to shapes). When displaying the log-file together with the visual outcome, users can make changes in the log file and discover what the result would be in the visualisation. Changes can be made in the "classical" way, using keyboard and mouse.

Reflect

In this mode, learners' reflection is stimulated. They can join or consult a gallery of creative outcomes and discuss their process/creations in a digital environment that enables collaborative media annotation.

MULTIPLE MODES OF LEARNING

Singewing Space allows for differentiating between modes of learning, ranging from free explorations to very specific learning paths, each connected to a different instruction technique.

Free Exploration

In this mode, learners can freely explore interactions between music, movement, and visuals within one of the first three modes of interaction (respond, create, and alter). Evidently, the use of certain system settings (e.g. sensors, Environments) will affect the learner's possibilities. For example, using the leapmotion® (only hand movement) differs from working with a kinect® camera (full body).

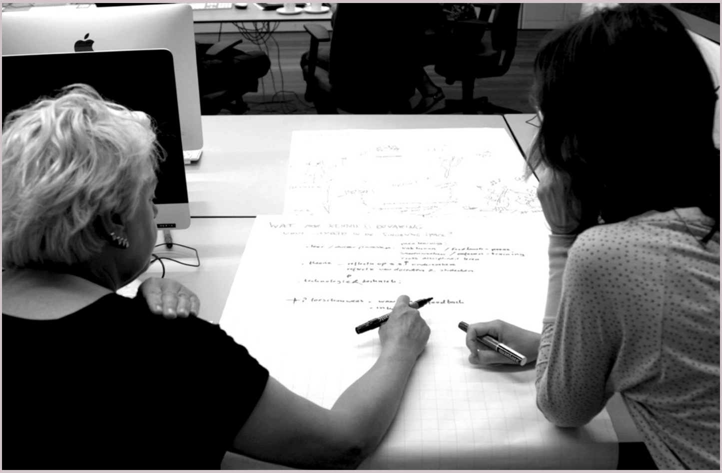
Guided Exploration

In this mode, learners can explore interactions between music, movement, and visuals within one of the first three modes of interaction (respond, create, and alter). In contrast to the Free Exploration mode, the explorations are only possibly within certain boundaries. That is, activities contain specific tasks with regard to different musical, movement, and visual parameters. These tasks can, for example, be given on the basis of game cards or shown by the virtual use. In the latter case, the behaviour of the virtual user is based on the measurement, collection, and analysis of data that is retrieved from the learners' engagement with the system (learning analytics).

Game Play
In this mode, learners engage in games that challenge their skills and creative interaction with music, movement, and visuals. These games build on the idea of guided exploration but introduce an extra motivating component. Moreover, they are based on learning analytics.

Learning Path
In this mode, learners perform specific tasks, designed to lead them towards a specific learning goal. The tasks shape a series of incremental steps. Each mode of learning can be accompanied by moments of reflection.

Starting from this initial concept, a research group was formed that aimed to develop a demonstrator that could illuminate a specific part of the Singewing concept: the interaction modes "creating and responding", and the modes of learning "free exploration, guided exploration, and game play" as will be described in the following paragraph.



3.2.
THE PROCESS OF DEVELOPMENT

DESIGNING SINGEWING SPACE THROUGH SPIRAL COLLABORATION

Typically, most contemporary real-time blended-learning research is primarily technology-driven. Development mainly deals with, for example, latency issues and optimisation techniques or motion tracking. However, this type of technology-driven research is too easily disconnected from educational aspirations. To ensure that Singewing Space was "*inspired by technology, but driven by pedagogy*" (OECD, 2010), a consortium of developers and researchers was formed that represented theoretical, music educational, and technological know-how. The consortium involved universities (University of Ghent and Erasmus University), applied universities of the arts (Codarts and Amsterdam University of the Arts), the creative industry (The Patching Zone), and a cultural centre (CKC Zoetermeer).

The research group took actual classroom practices as the starting point to think about activities connected to and in Singewing Space. To design these activities and to implement them in the design of the online application, the research group used the theories of embodied music cognition and participatory sense-making. In this way, the social and active physical involvement was given a prominent place in the way the learners are engaged in learning music. More specifically, the concepts of alignment, entrainment, and prediction were used in designing the different rhythm activities the learners had to undertake both online and offline.

In the development of the actual demonstrator, the research group worked together through spiral collaboration. This is an iterative process in which different partners with theoretical, technical, and practical backgrounds are included in the phases of its development. This way of working has the potential to lead to knowledge accumulation and to the improvement of practice (Van den Akker, Gravemeijer, McKenney & Nieveen, 2006). In Table 1 below the different phases are exemplified.

TABLE 1: *Phases in the development of the demonstrator Singewing Space*

DEVELOPMENT THEORETICAL AND PEDAGOGICAL FRAMEWORK SINGEWING SPACE WITH ALL PARTNERS, AND MUSIC AND DANCE TEACHERS	Researchers and practitioners: – developing theoretical and practice-based design principles that underpin the development of the concept of Singewing Space – deciding on which musical domain the focus of the demonstrator would be (rhythm skills)
EXPLORATION PHASE WITH ALL PARTNERS	– Hands-on experimentation with different (low-tech) interfaces and sensors – Exploring rhythm activities for online and offline lessons
DEVELOPMENT PHASE WITH ALL PARTNERS	– Developing a first demonstrator – Developing the first online and offline lessons
USER TESTING WITH LEARNERS AND TEACHERS OF CKC ZOETERMEER	– Testing rhythm activities of an offline lesson (lesson 5)
IMPROVEMENT PHASE WITH ALL PARTNERS	– Improving the demonstrator and the lessons based on the input of the users
USER TESTING WITH STUDENTS OF CODARTS AND THE ERASMUS UNIVERSITY	– Testing the demonstrator through rhythm activities of an online lesson (lesson 2)

TECHNICAL IMPLEMENTATION

The technical design of Singewing Space was informed by pedagogical principles and every technological and design decision was taken with an augmented blended-learning environment in mind. As such, widely available, standard, cost-effective, and cross-platform solutions were prioritised over high-end platform and hardware-dependent technologies. Furthermore, custom interaction design, optimised and focused for each part of the exercise was prioritised over standard general-purpose user interface. The chosen solution for the demonstrator took full advantage of web standards for sound (Web Sound API), graphics rendering (HTML, CSS, JS, SVG), networked communication, and the handling of sensor data (WebSocket).

Due to the central role of rhythm skills and body movement, accurate timing is an essential element in the Singewing Space concept. Therefore, a major challenge was to reduce latency in all the interactions, within the local machine and especially between machines in the networked environment. To make this possible, the WebSocket server acts mostly as a repeater, receiving a message from one of the clients and broadcasting it to all the others without manipulating or storing the data in any way. All data handling is deferred to the moment after the broadcast when timing is not so critical anymore. Another optimisation that greatly improved latency in the Websocket connections comes from keeping all the packets sent to a minimum size while still continuously sending messages even if they are not absolutely necessary. This is due to the fact that the WebSocket protocol is optimised to work more as a stream than a message-based communication system; sending packets continuously makes the system batch the frames into a continuous stream (Internet Engineering Task Force, 2011).

By adopting a web-browser environment and a flexible and responsive design, the demonstrator can easily and quickly be set up and run across a wide range of platforms and operating systems, both mobile (IOS, Android) and desktop (PC, Mac, and Linux). In terms of architecture, the system uses a lightweight, real-time optimised server (NodeJS) to both serve the application code to clients (Browsers) and handle all the communication between them. The application on the client side features hand-motion tracking (Leap Motion®), a custom adaptable algorithm to decide in which part of a fluid movement a beat should happen, a graphic visualisation of the movement of all the connected clients, a system that generates synchronised rhythmic patterns and plays them using different sounds, both recorded and synthesised, and a BPM (Beats Per Minute) analyser.

When learners connect in the virtual environment of Singewing Space they identify themselves by their name, colour, and sound. They can wave their hands to a rhythm and interact with the others in this virtual space. As they wave their hands, the system tries to predict acceleration peaks in their movement by keeping a moving average of the last 100 data points and triggering a beat when a threshold of 1.5 standard deviations is hit. In this way, the system can trigger the beats with as little delay as possible and adapt to any type of movement. The movement of each learner is shown on all the screens as a circle that leaves a trail of configurable length. As the BPMs of all the learners match within 5 BPM tolerance, everyone starts getting points. The score is kept for the whole group, there is no competition, it is an exclusively co-operative environment. The values of the number of data points for the moving average, the threshold, and BPM matching tolerance were fine-tuned based on user testing.

4. SINGEWING SPACE IN THE CLASSROOM

The Singewing Space demonstrator was specifically developed for augmented *blended* music learning. To connect the demonstrator to the classroom practice, five interrelated online and offline lessons focusing on rhythm skills were developed by the designers and music teachers. As rhythm is a fundamental feature of music, rhythm skills are viewed as a key element in music education (Flohr, 2005; Gordon, 2003). Rhythm skills include performing the pulse, metre, rhythms, rhythmic phrases, and different tempi of music at an individual level or group level; synchronising movements to rhythm aspects of an external musical source; expressing the character of a rhythm or the rhythmic style; and improvising rhythmically at an individual or group level (Bremmer, 2015).

4.1. OVERVIEW OF THE LESSONS

In the section below an outline is given of the developed offline and online lessons built around the development of the following rhythm skills:

- performing the pulse, metre, rhythmic phrases, and different tempi of music at an individual level or group level;
- synchronising movements to rhythm aspects of an external musical source;
- expressing the character of a rhythm;

– improvising rhythmically at an individual or group level.

The lessons were developed based on the idea that the online lesson helps pupils prepare for an offline lesson or supports the processing of offline-presented learning content. They were designed for pupils in the age of nine to eleven years old and last approximately 30 minutes each. On the following pages an overview of the lessons can be found.

LESSON 1: OFFLINE

Aims: Pupils are able to

- find and keep the pulse of the music as a group (social entrainment)
- feel the difference between a staccato (phase alignment) and flowing movement (inter-phase alignment) when moving to music
- depict the pulse in a visual way
- reflect on the drawings they made
- transform their drawings into a variety of rhythmical movements

Materials:

- a piece of music with a clear pulse, two pieces of music that each contain a contrast between staccato and legato
- drawing materials

Phase one: Warm-up

1. The music teacher asks the pupils if they can freely move to the pulse of the music;
2. The music teacher asks the pupils to repeat the activity, however, the music teacher will turn off the music at a certain point at which the pupils will have to try and keep moving to the pulse of the silenced music. The teacher will then switch on the music again and ask the pupils whether or not they were able to keep the pulse of the music without hearing it (check entrainment and prediction via synchronisation-continuation paradigm).

Phase two: Introducing legato and staccato

Activity one:

1. The class is divided into two groups (A and B) that stand opposite each other so they can see each other (social entrainment). The teacher puts on the first contrasting piece of music and asks Group A to make staccato movements to the music (provoke event-based timing strategy but see continuous movement), and group B flowing movements (provoke emergent timing strategy but see continuous movement). At the signal of the music teacher, the groups swap movements.

Activity two:

1. The music teacher asks the pupils to stand in a circle and hands every pupil a ball;
2. The teacher asks the pupils if they can find a legato pulse together by bouncing the ball to the floor (social entrainment and prediction of the movement of the ball);
3. Once the pupils have found a common pulse, the teacher asks the pupils to find a faster pulse together (entrainment). Once the pupils have found a faster common pulse, the teacher asks to find an even faster pulse together (staccato).

Phase three: Transforming and reflecting on legato and staccato

1. The music teacher puts on the second contrasting piece of music (legato and staccato) and asks pupils to make a drawing of the music;
2. In groups of four, the pupils reflect on each other's drawing, focusing on how they would translate the drawing of the other pupils into physical movements;
3. The pupils transform their drawings into a choreography of rhythmical movements.

LESSON 2: ONLINE

Aims: Pupils are able to

- find and keep the pulse of the music as a group (social-entrainment)
- show the difference between a staccato (phase alignment) and flowing movement (inter-phase alignment) when moving to music
- transform visuals into a variety of rhythmical movements

Activity one in the Singewing Space environment:

1. The pupils have to find a common pulse together in the Singewing Space environment. By pretending to bounce a ball, the pupils can create a visualisation and the sound of the pulse in the virtual environment. Once an audible and visual common pulse is found, the group wins a star and receives a new assignment;
2. The group now has to find a faster pulse and once an audible and visual common pulse is found, the group wins a star and receives a new assignment. The group has to keep finding faster pulses until they have won four stars. After the fourth star, the group proceeds to a 'higher level'.

Activity two in the Singewing Space environment:
Singewing Space generates music and the pupils try to make movements that fit the character of the music (which varies between legato or staccato music) and that are visualised in the online environment. If the movements of the whole group match the legato or staccato character of the music, the group wins a star. After the fourth star, the group proceeds to a 'higher level'.

Activity three in the Singewing Space environment:
One pupil moves to the music, creating a visualisation of the movement in the online environment. Another pupil then has to transform the visualisation to movements that create new visualisations in the online environment etcetera.

LESSON 3: OFFLINE

Aims: Pupils are able to

– demonstrate their sense of rhythm through movement
– demonstrate musical phrases of 2, 4, and 8 beats through movement
– demonstrate movements on the beat (phase alignment) and in-between the beats (inter-phase alignment)
– compose a rhythm loop of 8 beats, making use of body percussion, vocals, and instruments
– reflect on which sequence of rhythm loops sounds the best.

Materials:

– a piece of music that contains a contrast between staccato and legato
– pop songs e.g. I Want You Back (Jackson 5) or The Lazy Song (Bruno Mars)
– instruments

Phase one: Warm-up

1. A piece of music is played and pupils try to make movements that fit the character of the music (which varies between legato or staccato music).
2. The music switches between legato or staccato music, and the pupils who do not adjust their movements in time, have lost the game.

Phase two: Introducing rhythmic phrases

Activity one

1. The pupils choose a place in the classroom. First, they listen to the music and clap on the 1st beat of a 4-beat measure and move freely to the other beats.
2. After a while, they clap on the 1st and 3rd beat of the 4-beat measure and move freely on the other beats of the measure.
3. Lastly, they clap on all 4 beats of the 4-beat measure and move freely on the time in-between the beats.

Activity two

1. Pupils make groups of three, stand in a triangle, and face each other. A first pupil claps to the 1st beat of a 4-beat measure and moves freely to the other beats. A second pupil claps to the 1st and 3rd beat of the 4-beat measure and moves freely to the other beats. A third pupil claps to all 4 beats of the 4-beat measure. The teacher then cues the pupils to swap places in the triangle, and the pupils now have to find the '1' in the 4-beat measure and clap the rhythm of the other pupil.

Activity three

1. The pupils form a double line, facing each other. On the pulse of the music, the pupils walk towards each other on an 8-beat phrase, and clap the hands of the pupil standing opposite them on the 8th beat. The pupils then walk backwards again on an 8-beat phrase to their initial place in the line and stomp their foot on the 8th beat.
2. Now, the pupils walk towards each other on a 4-beat phrase, and clap the hands of the pupil standing opposite them on the 4th beat. The pupils then walk backwards again on a 4-beat phrase to their initial place in the line and stomp their foot on the 4th beat.
3. Now, the pupils walk towards each on a 2-beat phrase, and clap the hands of the pupil each other on standing opposite them on the 2nd beat. The pupils then walk backwards again on a 2-beat phrase to their initial place in the line and stomp their foot on the 2nd beat.
4. Lastly, the pupils walk towards each other on 1 beat and clap on that beat. The pupils then walk backwards again on a 1-beat phrase to their initial place in the line.

Phase three: Transforming and reflecting on rhythmic phrasing

1. The pupils make groups of four. They compose a rhythmic loop of 8 beats, making use of body percussion, vocals, and instruments.
2. The different loops of the groups are connected to make one rhythm composition. The class reflects on which sequence of loops sounds the best.

LESSON 4: ONLINE

Aims: Pupils are able to

– demonstrate musical phrases of 2, 4, and 8 beats through movement (alignment and entrainment)

Activity one in the Singewing environment:
The pupils select a music piece. The first pupil makes an arc movement to an 8-beat phrase with his or her arms (Singewing Space visualises this movement, e.g. in orange). Simultaneously, the second pupil makes an arc movement to a 4-beat phrase with his or her arms (Singewing Space visualises this movement, e.g. in blue). The third pupil makes an arc movement to a 2-beat phrase with his or her arms (Singewing Space visualises this movement, e.g. in green). See Figure 4.

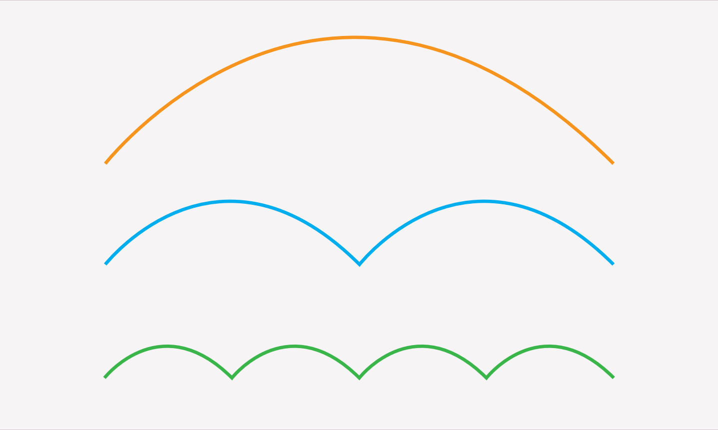


FIGURE 4

In the second part of the activity, the computer cues the pupils to change their rhythmic phrasing. See Figure 5.

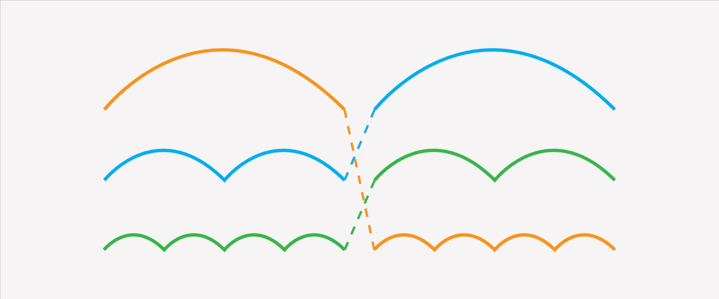


FIGURE 5

To develop a sense of phrasing throughout different styles, this activity can be done with European classical music, jazz, pop, or traditional music.

LESSON 5: OFFLINE

Aims: Pupils are able to

- demonstrate their sense of rhythm through movement (alignment)
- demonstrate musical phrases of 2, 4, and 8 beats through movement (alignment)
- reflect on which rhythm loop sounds the grooviest
- improvise an 8-beat phrase (entrainment and prediction)

Materials:

- a piece of music that contains a contrast between staccato and legato
- pop songs e.g. I Want You Back (Jackson 5) or The Lazy Song (Bruno Mars)
- instruments

Phase one: Warm-up

Activity one:

1. The pupils stand in half a circle and listen to the music and make a fluid arc movement to an 8-beat phrase with their arms. Afterwards, the pupils are asked to demonstrate discrete (staccato) movements to every beat of the 8-beat phrase. When the teacher claps his or her hands, the pupils switch from making a fluid arc movement to making discrete movements and vice versa.

Phase two: Experimenting with rhythmic phrases

1. During the next step of the activity, one third of these pupils form a second half circle, sitting on their knees and facing the other pupils. These pupils make a fluid arc movement to a 4-beat phrase with their arms. Afterwards, the pupils are asked to demonstrate discrete (staccato) movements

to every beat of the 4-beat phrase. When the teacher claps his or her hands, the pupils switch from making a fluid arc movement to making discrete movements and vice versa.

2. The two groups of pupils combine their movements whilst looking at each other. When the teacher claps his or her hands, the pupils switch from making a fluid arc movement to making discrete movements to their rhythmical phrase and vice versa.
3. Another third of the pupils forms a line in-between the two half circles and sits down on the floor (in this way, all the pupils are able to see each other). These pupils make a fluid arc movement to a 2-beat phrase with their arms. Afterwards, the pupils are asked to demonstrate discrete (staccato) movements to every beat of the 2-beat phrase. When the teacher claps his or her hands, the pupils switch from making a fluid arc movement to making discrete movements and vice versa.
4. The two groups of pupils combine their movements whilst looking at each other. When the teacher claps his or her hands, the pupils switch from making a fluid arc movement to making discrete movements to their rhythmical phrase and vice versa.
5. The pupils now stand in a triangle and every side of the triangle gets assigned an 8-, 4-, or 2-beat phrase. When the teacher cues the pupils, they switch phrases: the side assigned the 8-beat phrase switches to the 2-beat phrase (and then to the 4-beat phrase, to the 8-beat phrase, to the 2-beat phrase, etc.), the side assigned the 4-beat phrase switches to the 8-beat phrase (and then to the 2-beat phrase, to the 4-beat phrase, to the 8-beat phrase, etc.) and the side assigned the 2-beat phrase switches to the 4-beat phrase (and then to the 8-beat phrase, to the 2-beat phrase, to the 4-beat phrase, etc.)

6. When the teacher claps once the pupils switch phrases, when the teacher claps twice the pupils switch making a fluid arc movement with their arms, to making discrete (staccato) movements to every beat of their phrase.

Phase three: Transforming and reflecting on rhythmic phrasing through a "Rhythm Rondo"

1. The pupils recall the rhythm loop of 8 beats they composed the lesson before.
2. The class reflects on which rhythm loop sounds the grooviest.
3. The class stands in a circle and performs the improvisation "Rhythm Rondo". The class performs the rhythm loop (refrain) and individual pupils or small groups of pupils improvise an 8-beat couplet through body percussion, vocals, or on instruments.

“The domain of music education displays a growing demand for innovative technological learning environments that relate to its highly multimodal way of teaching and learning.”

Bauer, 2014

5. DISCUSSION AND CONCLUSION

In this publication, we have presented a novel approach to blended learning that introduces an "embodied" stance by augmenting the online component of blended learning with different movement sensors and with visualisations that promote the blending with classroom activities. The approach also stimulates cooperative learning by promoting participatory sense-making through the co-creation of visualisations. This approach was exemplified in our description of the concept of a new application, Singewing Space. This educational technology consists of an online learning environment that encompasses a customisable Virtual Space. It seeks to promote participatory sense-making in the domain of music by providing opportunities to collaboratively engage in a multimodal interaction with music, in or outside the classroom. Although the system is in its initial stages of development and empirical evaluation and validation are currently lacking, we strongly believe in its potential for several reasons.

A first reason is the fact that the domain of music education displays a growing demand for innovative technological learning environments that relate to its highly multimodal way of teaching and learning (Bauer, 2014). According to Savage (2009), such technological innovations might be a "force of change", introducing new approaches that address the shortcomings of the so-called traditional teaching approaches. Despite ample technological applications for education, technological applications for music education are still in its infancy (Van den Dool, 2016). Secondly, the concept of Singewing Space is embeded in a rich and elaborated pedagogical-musicological framework (see also Nijs & Bremmer, forthcoming). This framework provides important insights into the nature of learning and interacting with music, which should be integrated into the design in order to develop adequate systems (Leman & Nijs, 2017; Nijs, 2017). A third reason is that the concept originates in a previously developed similar tool, the Music Paint Machine, which helps to avoid certain pitfalls and to use insights from the different studies and teaching experiences (Nijs et al., 2012, 2014, 2016). A fourth reason is the nature of the development process, which encompasses a close interaction with scholars, educators, and engineers. Through spiral collaboration, the concept is refined and elaborated in such a way that the design is inspired by technology but driven by pedagogy (OECD, 2010).

To conclude, we believe that an augmented blended-learning approach is key to bringing online learning in music education to a next level. The development of Singewing Space may contribute to the generation of insights into this approach and its potential for a music education of the future.

REFERENCES.

Anderson, M. (2003). Embodied cognition: A field guide. *Artificial Intelligence, 149*(1), 91-130.

Anderson, T. (2004). *Towards a theory of online learning. Theory and Practice of Online Learning, 2*, 109-119.

Arkorful, V., & Abaidoo, N. (2014). The role of e-learning, the advantages and disadvantages of its adoption in higher education. *International Journal of Education and Research, 2*(12), 397-410.

Azevedo, R., & Cromley, J.G. (2004). Does training on self-regulated learning facilitate students' learning with hypermedia? *Journal of Educational Psychology, 96*(3), 523-535.

Bauer, W.I. (2014). *Music learning today: Digital pedagogy for creating, performing, and responding to music.* New York: Oxford University Press.

Bennet, M., Schatz, M., Rockwood, H., & Wiesenfeld, K. (2002). Huyghens's clocks. Proceedings: Mathematics. *Physical and Engineering Sciences, 458* (2019), 563-579.

Bos, N.R. (2016). *Effectiveness of blended learning-factors facilitating effective behavior in a blended learning environment* (Unpublished PhD thesis). Open University of the Netherlands, Heerlen, NL.

Bowman, W.D. (2004). Cognition and the body: Perspectives from music education. In L. Bresler (Ed.), *Knowing bodies, moving minds: towards embodied teaching and learning* (pp. 29-50). Dordrecht: Kluwer Academic Publishers.

Braun Janzen, T., Thompson, W.F., & Ranvaud, R. (2014). A developmental study of the effect of music training on timed movements. *Frontiers in Human Neuroscience, 8*, 801.

Bremmer, M. (2015). *What the body knows about teaching music: The specialist preschool music teacher's pedagogical content knowing regarding teaching and learning rhythm skills viewed from an embodied cognition perspective* (Unpublished PhD thesis). University of Exeter, UK.

Bremmer, M. (2015). What the body knows about teaching music. In M. Bremmer & C. Hermans, *Embodiment in arts education. Teaching and learning with the body in the arts* (pp. 14-27). Amsterdam: Lectoraat Kunst- en cultuureducatie.

Center for Blended Learning. (n.d.). Blended learning: wat, hoe en waarom? Retrieved from: https://www.kuleuven-kulak.be/BlendedLearning/Blended%20learning/blended-learning.

Clayton, M., Sager, R., & Will, U. (2004). In time with the music: The concept of entrainment and its significance for ethnomusicology. *ESEM CounterPoint, 1*, 1-45.

Cogdill, S.H. (2015). Applying research in motivation and learning to music education: What the experts say. *Update: Applications of Research in Music Education, 33*(2), 49-57.

Csikszentmihalyi, M. (1990). *Flow: The psychology of optimal experience*. New York: Harper & Row.

Dahl, S., & Huron, D. (2007). The influence of body morphology on preferred dance tempos. *In Proceedings of the international computer music conference (vol. 2, pp. 1-4)*. New York/ Copenhagen: International Computer Music Association, San Franscisco.

Davis, N., Hsiao, C.P., Singh, K., Li, L., & Magerko, B. (2016). Empirically studying participatory sense-making in abstract drawing with a co-creative cognitive agent. *In Proceedings of the 21st International Conference on Intelligent User Interfaces* (196-207).

De Jaegher, H., & Di Paolo, E. (2007). Participatory sense-making: An enactive approach to social cognition. *Phenomenology and the Cognitive Sciences, 6*(4), 485-507.
Dourish, P. (2004). *Where the action is: The foundations of embodied interaction*. Cambridge, MA: The MIT Press.
Eerola, T., Luck, G., & Toiviainen, P. (2006). An investigation of pre-schoolers' corporeal synchronization with music. In M. Baroni, A.R. Addessi, R. Caterina, & M. Costa (Eds.), *Proceedings of the 9th international conference on music perception and cognition* (pp. 472-476). Bologna: Alma Mater Studiorum University of Bologna.
Flohr, J.W. (2005). *Musical lives of young children*. Upper Saddle River: Prentice-Hall.
Foglia, L., & Wilson, R.A. (2013). Embodied cognition. *Wiley Interdisciplinary Reviews: Cognitive Science, 4*(3), 319-325.
Foertsch, J., Moses, G., Strikwerda, J., & Litzkow, M. (2002). Reversing the lecture/homework paradigm using eTEACH web-based streaming video soft-ware. *Journal of Engineering Education, 91*(3), 267-274.
Gallagher, S. (2017). *Enactivist interventions: Rethinking the mind*. Oxford: Oxford University Press.
Garrison, D.R., & Kanuka, H. (2004). Blended learning: Uncovering its transformative potential in higher education. *The Internet and Higher Education, 7*(2), 95-105.
Graham, C.R. (2006). Blended learning systems. In C.J. Bonk & C.R. Graham (eds.). *The handbook of blended learning*. San Francisco, CA: Pfeiffer.
Gordon, E.E. (2003). *A music learning theory for newborn and young children*. Chigaco, IL: GIA Publications.
Hannaford, C. (1995). *Smart moves: Why learning is not all in your head*. Arlington: Great Ocean Publishers.
Hattie, J., & Timperley, H. (2007). The power of feedback. *Review of Educational Research, 77*(1), 81-112.

Hopman, M. (1999). *Creatieve processen. Over studie- en beroepshouding van kunstenaars.* Assen: Van Gorcum B.V.

Hua, L.V., Goodwin, D., & Weiss, A. (2013). Traditional vs. blended learning of pharmacology. *Optometric Education, 39*(1).

Huys, R., Studenka, B.E., Rheaume, N.L., Zelaznik, H.N., & Jirsa, V.K. (2008). Distinct timing mechanisms produce discrete and continuous movements. *PLOS Computational Biology, 4*(4), e1000061.

Internet Engineering Task Force (2011). The WebSocket Protocol - RFC 6455. Retrieved from: https://tools.ietf.org/html/rfc6455.

Janzen, T.B., Thompson, W.F., Ammirante, P., & Ranvaud, R. (2015). Timing skills and expertise: Discrete and continuous timed movements among musicians and athletes. *Frontiers in Psychology, 5*.

Johnson, D.W., & Johnson, R.T. (2014). Cooperative learning in the 21st century. *Anales de Psicología/Annals of Psychology, 30*(3), 841-851.

Leman, M. (2016). *The expressive moment. How interaction (with music) shapes human empowerment.* London: The MIT Press.

Leman, M. (2007). *Embodied music cognition and mediation technology.* London: The MIT Press.

Leman, M., & Nijs, L. (2017). Music cognition and technology-enhanced learning for music playing. In A. King, E. Himonides, & A. Ruthman (Eds.), *The Routledge companion to music, technology, and education* (pp. 225-242). London: Routledge

Macdonald, J. (2008). *Blended learning and online tutoring* (2nd ed.). Hampshire: Gower.

Moskal, P., Dziuban, C., & Hartman, J. (2013). Blended learning: A dangerous idea? *The Internet and Higher Education, 18*, 15-23.

Moore, M.G., & Kearsley, G. (2011). *Distance education: A systems view of online learning.* Boston: Cengage Learning.

Nijs, L., & Bremmer, M. (forthcoming). Embodiment and early childhood music education. In B. Ilari & S. Young (Eds.), *Music in Early Childhood*. Springer.

Nijs, L. (2017). Dalcroze meets technology. Integrating music, movement and visuals with the Music Paint Machine. *Music Education Research, 20*(2), 163-183.

Nijs, L., & Leman, M. (2016). Performing with the Music Paint Machine: Provoking an embodied approach to educational technology. In A. King & E. Himonides (Eds.), *Music, Technology & Education: Critical Perspectives* (pp.225-242). London: Ashgate.

Nijs, L., & Leman, M. (2014). Interactive technologies in the instrumental music classroom: A longitudinal study with the Music Paint Machine. *Computers and Education, 73,* 40-59

Nijs, L., Coussement, P., Moens, B., Amelynck, D., Lesaffre, M., & Leman, M. (2012). Interacting with the Music Paint Machine: Relating the concepts of flow experience and presence. *Interacting with Computers, 24*(4), 237-250.

Nijs, L., Moens, B., Lesaffre, M., & Leman, M. (2012). The Music Paint Machine: Stimulating self-monitoring through the generation of creative visual output using a technology-enhanced learning tool. *Journal of New Music Research, 41*(1), 79-101.

Nijs, L., & De Baets, Th. (Eds.) (2015). *Muziekpedagogiek in beweging. Technologie als medium.* Heverlee: Eurprint Ed.

OECD (2010). *Inspired by technology, driven by pedagogy: A systemic approach to technology-based school innovations, educational research and innovation*. Paris: OECD Publishing.

OECD (2015). *Students, computers and learning. Making the*

Connection. Paris: OECD Publishing.

Oliver, M. & Trigwell, K. (2005). Can "blended learning" be redeemed? *E-learning, 2*(1), 17-26.

Phillips-Silver, J., Aktipis, C.A., & Bryant, G.A. (2010). The ecology of entrainment: Foundations of coordinated rhythmic movement. *Music Perception, 28*(1), 3-14.

Piaget, J. (1964). Cognitive development in children: Piaget development and learning. *Journal of Research in Science Teaching, 2*(3), 176-186.

Poon, J. (2013). Blended learning: An institutional approach for enhancing students' learning experiences. *Journal of Online Learning and Teaching, 9*(2), 271.

Price, S., Roussos, G., Pontual Falcao, T., & Sheridan, J.G. (2009). Technology and embodiment: Relationships and implications for knowledge, creativity and communication. *Beyond Current Horizons: Technology, children, schools and families.*

Puustinen, M., & Pulkkinen, L. (2001). Models of self-regulated learning: A review. *Scandinavian Journal of Educational Research, 45*(3), 269-286. Retrieved from www.beyondcurrenthorizons.org.uk/wp- content/uploads/ch3_final_sarahpricefinal.pdf.

Savage, J. (2009). Pedagogical strategies for change. In J. Finney & P. Burnard (Eds.), *Music Education with Digital Technology* (pp. 142-155). London: Continuum.

Schiavio, A., & De Jaegher, H. (2017). Participatory sense-making in joint musical practice. In Lesaffre, M., Maes, P.-J, & Leman, M. (Eds.) *Routledge companion to embodied music interaction* (pp. 31-39). London: Routledge.

Schroeder, C.E., Wilson, D.A., Radman, T., Scharfman, H., & Lakatos, P. (2010). Dynamics of active sensing and perceptual selection. *Current Opinion in Neurobiology, 20*(2), 172-176.

Sheets-Johnstone, M. (2011). *The primacy of movement.* Amsterdam/Philadelphia: John Benjamins Publisher Company.

Sievers, B., Polansky, L., Casey, M., & Wheatley, T. (2013). Music and movement share a dynamic structure that supports universal expressions of emotion. *Proceedings of the National Academy of Sciences 110*(1), 70-75.

Spanjers, I.A.E., Könings, K.D., Leppink, J., & Van Merriënboer, J.J.G. (2014). *Blended leren: Hype of verrijking van het onderwijs? Rapportage voor Kennisnet.* Retrieved from https://onderzoek.kennisnet.nl/app/uploads/2016/12/KennisnetverslagBlendedLeren.pdf.

Spanjers, I.A., Könings, K.D., Leppink, J., Verstegen, D.M., de Jong, N., Czabanowska, K., & van Merriënboer, J.J. (2015). The promised land of blended learning: Quizzes as a moderator. *Educational Research Review, 15*, 59-74.

Steels, L. (Ed.). (2015). *Music learning with massive open online courses (MOOCs)* (vol. 6). Amsterdam: IOS Press.

Stern, D.N. (2010). *Forms of vitality: Exploring dynamic experience in psychology, the arts, psychotherapy, and development.* New York: Oxford University Press.

Svanum, S., & Bigatti, S.M. (2009). Academic course engagement during one semester forecasts college success: Engaged students are more likely to earn a degree, do it faster, and do it better. *Journal of College Student Development, 50*(1), 120-132.

Thomas, G. (2013). *Education: A very short introduction.* Oxford: Oxford University Press.

Vygotsky, L.S. (1978). *Mind in society: The development of higher psychological processes.* Cambridge MA: Harvard University Press.

Torre, K., & Balasubramaniam, R. (2009). Two different processes for sensorimotor synchronization in continuous and discontinuous rhythmic movements. *Experimental Brain Research, 199*(2), 157-166.

Tricomi, E., & De Pasque, S. (2016). The role of feedback in learning and motivation. In S. Kim, J. Reeve, & M. Bong (Eds.) *Recent developments in neuroscience research on human motivation (advances in motivation and achievement, vol. 19)* (pp.175 - 202). Bingley: Emerald Group Publishing Limited.

Van den Akker, J., Gravemeijer, K., McKenney, S., & Nieveen, N. (2006). *Education design research.* London: Routledge.

Van den Dool, J. (2016). Musical safe space. Conference paper: *International Conference on Education and New Learning Technologies,* Barcelona, July 7, 2016.

Van den Dool, J. & Van Baalen, W. (2017). *Codarts, Canvas en blended learning: de waarde van Canvas voor het artistieke leerproces.* Unpublished manuscript.

Van den Dool, J. (2018). *Move to the music: Understanding the relationship between bodily interaction and the acquisition of musical knowledge and skills in music education.* PhD dissertation, Erasmus University Rotterdam.

Voogt, J., Sligte, H.W., Beemt, A. van den, Braak, J. van, & Aesaert, K. (2016). *E-didactiek. Welke ict-applicaties gebruiken leraren en waarom?* Amsterdam: Kohnstamm Instituut.

Zelaznik, H.N., Spencer, R., & Ivry, R.B. (2002). Dissociation of explicit and implicit timing in repetitive tapping and drawing movements. *Journal of Experimental Psychology: Human Perception and Performance, 28*(3), 575-588.

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SINGEWING SPACE
An augmented blended-learning approach to music learning

by
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Digital Art Lab, CKC

thanks to: Wander van Baalen (Codarts), David Jonas (The Patching Zone), Anne Nigten (The Patching Zone), Joep Annegarn (CKC & partners), Piem Wirtz (Digital Art Lab, CKC)

editing: Rebekka Bremmer
design: Maaike Besseling
photos: Jordy Bouter, Anne Nigten, Thijmen de Valk and Piem Wirtz
printing: Veenman+
publisher: Amsterdam University of the Arts in cooperation with Codarts

This research was financed in collaboration with Regieorgaan SIA, part of The Netherlands Organisation for Scientific Research (NWO).

ISBN: 978-90-71681-41-7

Research Group Arts Education
The Research Group Arts Education of the Amsterdam University of the Arts focuses on knowledge development and education development in the field of arts education. The Research Group is headed by Melissa Bremmer and Emiel Heijnen.

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SINGEWING SPACE

Music education has only scarcely embraced blended modes of learning. Moreover, existing applications often involve classical ways of online learning. In this project, we present the concept and a demonstrator of Singewing Space, a web-based interactive educational technology that introduces a novel approach to blended learning in music education, based on an 'embodied' and collaborative approach to music learning. The concept of Singewing Space not only exemplifies how face-to-face learning can be connected to online learning (blended) but also how the use of various sensors can be applied in online learning (augmented). It shows how playing, singing, and moving to music, alone or jointly with peers, can be integrated by using motion capturing in combination with sound recording. In this way, this application aims to stimulate the collaborative creation of a visualisation of music or movement in a virtual learning environment.

Learners are invited to respond to each other's creations through meaningful musical and physical actions. The online activities are always representative of classroom activities. The demonstrator illuminates a specific part of the Singewing concept: how learners can create rhythms through movement, how these rhythms can be visualised, and how learners can respond rhythmically to each other in a virtual learning environment.

Amsterdam University of the Arts