Innovations Workshops

Future music: investigating the role of technology in enhancing public appreciation of and participation in music

An Insight Paper

by Teresa Dillon

CONTENTS

The Futurelab Innovations Workshop series aims to help pioneer new ways of designing and using emerging digital technologies. By bringing together experts from the creative, education and technology communities, our aim is to create a space where practitioners can discuss the future of digital technologies for learning. One of the 2005 series of workshops was on music technology. Specifically this workshop addressed the role of technology in enhancing public appreciation of and participation in making and listening to music.

This document provides an overview of the key trends which informed our discussions during the workshop and the outcomes of the workshop day.

1. WORKSHOP FOCUS

1. **Musical networks and interfaces:** where do the new opportunities lie and how can we build meaningful musical experiences using integrated, pervasive networks?

2. **New musical practices for the 21st century:** to support innovations in teaching music using digital technologies, what kinds of learning contexts do we need to develop?

To address these questions, we invited relevant practitioners to present and showcase their work. Working in small groups we developed 'future visions' of how music technologies will enhance public appreciation of and participation in making and listening to music in the year 2015. These 'visions' are summarised within this paper.

2. INTRODUCTION

Music technology is often discussed in relation to secondary education, where it is used prolifically (keyboards, computers, electronic instruments) and has become a recognised subject area in its own right. However in discussing future scenarios it is important to acknowledge the relevance of music in children and young people's lives, and the musical cultures and communities that emerge in and around clubs, garages, rehearsal spaces, homes, arts centres, conservatoires and schools. The work discussed in the following sections attempts to pull together research across formal and non-formal learning sectors and the creative and software industry. This is not an exhaustive review but an indication of current trends in the field.

2.1 Music technology in school settings

Music technologies (keyboards, computers) were first introduced into UK secondary school classrooms during the early 1980s. Since then there has been a steady growth in the availability of ICT across the curriculum. However it was not until the 1990s that music technologies were explicitly referred to in the National Curriculum. Although they are currently advocated at all key stages, it is not until Key Stage 3 that they are specifically referred to as a means "to explore, create and record sound" (National Curriculum Orders for Music Education, in Rogers 1997).

In a recent survey carried out by the Office for Standards in Education (Ofsted), findings indicated that:

> "ICT has had a positive impact on teaching and learning in music in the majority of secondary schools. Music technology is often used successfully to enhance the

> development of a wide range of musical skills, as well as being an area of study in its own right." (Ofsted 2004, p4)

Despite several survey reports on the application of music technologies within schools (Dillon et al 2001; Mills and Murray 2000; Ofsted 2002a, 2002b, 2004; Pitts and Kwami 2002), little detailed work has been carried out on how they actually influence learners' processes (creative, collaborative or individual) and musical understandings. Research that has been carried out across various primary (Mellor 2001), secondary (Dillon 2003, 2004; Folkestad, Hargreaves and Lindström 1998; Seddon and O'Neill 2001) and non-formal (Dillon 2004) learning settings has focused on different technologies and research questions, and so although our knowledge is steadily growing, work in the field has tended to be sporadic and centred on individual researchers' interests and orientations.

For example, studies have shown that teaching practices tend to focus around particular hardware and sequencing or notation packages. Consequently learners' experiences are limited and the full potential of music technologies has not yet been fully explored in school. As noted in the recent Ofsted report:

> "Most music departments base the majority of work in music technology on one piece of software – typically either sequencing or score-writing. This can result in pupils gaining limited experience in the wide-ranging applications of ICT in music. A minority of departments make good use of a range of software, including audio editing programs and CD-Roms to develop skills such as aural perception and understanding of musical form and history." (Ofsted 2004, p4)

Consequently innovation in music teaching with technology tends to be driven by individual teachers who are passionate and interested in this area. Similar to the use of ICT in art (eg refer to Arts Council of England, 'Keys to Imagination ICT in Art Education', 2003), exemplary music technology practices are unusual and sometimes little known outside the school or department context.

This is not to take away from the successes of music technology in schools. Various surveys (Mills and Murray 2000; Ofsted 2004) have reported that teachers find music technology opens up the curriculum and allows all abilities access to music. In addition technology provides teachers with an additional toolkit through which they can engage young people in the sophisticated process of composition (eg through sequencing packages such as Cubase and sampling software such as eJay) as well as enhancing music appreciation (eg through the use of CD-Roms, web etc). Teachers have also cited more functional benefits of using computers for storing, saving and retrieving music, which they find useful to track pupils' progress (Dillon forthcoming; Dillon et al 2001; Mills and Murray 2000; Ofsted 2004; Pitts and Kwami 2002). On a negative note, some of the most commonly cited problems with using ICT in music are lack of funds, inadequate training and lack of technical support, particularly when computers crash etc (Dillon forthcoming; Dillon et al 2001; Mills and Murray 2000; Ofsted 2004; Pitts and Kwami 2002).

From our perspective, it is necessary to not only share examples of exemplary school practices but also discuss how schools can become sites of musical innovation, which embody both traditional and contemporary approaches to music, by providing rich musical experiences for all ages and abilities.

2.2 Music technology in non-formal educational settings

The influence of music and its mediating role in the construction and negotiation of developing identities and communication has been well documented (eg refer to MacDonald, Hargreaves and Miell 2002). Therefore when discussing future innovations in music technology, we need to consider the profound influence music has on our developing sense of identity, our values and beliefs, and its relevance in young people's lives.

In relation to the kinds of music technology practices that exist outside formal, school contexts, research from the fields of education (Green 1998), media studies (Sefton-Green 1999) and social psychology (Dillon 2003) have attempted to examine the practices engaged in by musicians when learning in community and peer contexts. Green (1998) has found that musicians who learn outside formal, didactic teaching situations, generally teach themselves or 'pick up' skills and knowledge, usually with the help or encouragement of their family and peers, by watching and imitating musicians who are physically around them or from recordings or performances and other live events involving their chosen form of music.

In this respect, non-formal music-making practices are similar to what sociocultural theorists such as Rogoff (1990) and Brown, Collins and Duguid (1989) refer to as "apprenticeship models of learning", and to Lave and Wengers' (1991) idea of legitimate peripheral participation, where the newcomer or novice learner learns the skills and practice of the community by actively participating in meaningful, authentic learning situations. Such approaches to learning music are often linked to pop, rock and hip-hop (Cohen 1991; Rosenbrock 2002); traditional and world music (Cope 2001; McCarty 1997, 1999; Oehrle 1991) and jazz (Berliner 1994). Findings from this kind of research indicate the importance of peer networks, collaboration, freedom, autonomy and trust in developing a sense of musicianship and musical identity.

Consequently when discussing the role of emerging technologies and the role they play in music education, it is necessary to consider how musicians' identities are formed, how technology can support this and how non-formal music practices can be best utilised. Greater understandings of research in this area will help develop rich, musical experiences.

2.3 Online music cultures

Research in cultural and popular music studies also offers valuable insights into the practices that have emerged from, through and around the use of various audio and sound technologies (Cox and Warner 2004; Troop 2004), from studio equipment (Hebdige 1993), to Walkmans (du Gay, Hall, James, Mackay and Negus 1997), to the internet and iPods (Quantum 2004; Toynbee 2003). This body of work demonstrates the influence of technologies as music-making tools and how individuals use and repurpose them for their own musical ends.

However since the innovation of cassette tapes and home recording devices in the 1970s, the music industry has continually tried to control and legitimise the practices of music production, copying and distribution (Chestermann and Lipman 1988; Plumleigh 1990). The current proliferation of high-speed, wireless networks and peer-to-peer file sharing has changed and challenged the global music market (Fessenden 2002; Toynbee 2001). Despite the music industry's continual clampdown on peer-to-peer networks and file sharing, independent studies (Goetz 2004; Oberholzer and Strumpf 2004) show that their 'cries' of sale loss are in some cases unsubstantiated.

In sum, today we live in a 'download' culture; how we create, share and listen to music is directly influenced by our increasingly networked world.

In relation to our discussion, it's essential we discuss the relevance of peer-to-peer networks, file sharing and mobile music devices on contemporary music making and sharing. It is still open as to the kinds of interactions and practices that will emerge from the everyday use of connected online music devices. In considering future visions of music, the possibilities and implications of these devices were discussed.

3. SNAPSHOTS: INNOVATIVE EXAMPLES OF DESIGN AND RESEARCH IN MUSIC TECHNOLOGIES

The following section provides an overview of innovative projects selected by the author and workshop facilitators in this field. These projects were used to support thinking and brainstorming new ideas.

3.1 Interconnected Musical Networks (IMNs)

Interconnected Musical Networks (IMNs) (Weinberg 2002a) are computer systems that allow players to independently share and shape each others' music in real-time. The history of IMNs can be traced back to Cage's early experimentations with interconnected transistor radios which inspired groups like the Oakland, California group, League of Automatic Music Composers (Bischoff, Gold and Horton 1978). The League evolved into a subsequent group in 1987, called the Hub, which employed more accurate communication schemes by using the MIDI protocol to compose music by networking PC computers (Gresham-Lancaster 1998). As the internet developed, early systems were developed to enhance joint composition processes (eg NetJam Latta 1991). NetJam allowed a community of users to collaborate and produce music in an asynchronous way by exchanging MIDI files through e-mail. Later William Duckworth's 1997 piece, 'Cathedral', was one of the first interactive music works created specifically for the web where live events composed by users were broadcast online (for details of this work refer to Duckworth 1999). Further developments in this area such as The Beatbug Network and F@ust Music On-line (FMOL) are described below.

3.1.1 The Beatbug Network

The Beatbug Network is one of the Hyperinstruments developed though the MIT Media Lab's Hyperinstruments/Opera of the Future group that was used during the Toy Symphony project.

The Beatbugs[1] are palm-sized, hand-held, digital musical instruments that were initially designed to provide a formal introduction to mathematical concepts in music through an expressive and rhythmic group experience. Multiple Beatbug players can form an interconnected musical network - The Beatbug Network[2]. By synchronising with each other, users can trade sounds and control each other's music. When connected, the Beatbugs have been found to encourage collaborative creativity and composition and social play. For more technical details on The Beatbugs and similar hand-held musical instruments refer to Weinberg (2002b), Weinberg, Aimi and Jennings (2002) and Weinberg, Lackner and Jay (2000).

3.1.2 Hyperinstruments/Opera of the Future group

Using instruments such as The Beatbugs, MIT's Hyperinstruments/Opera of the Future group[3] developed large-scale, international projects that demonstrated how artificial intelligence, haptic and interactive interfaces could be used to facilitate collaborative musical interactions between professional musicians, young learners and the general public within art, community and orchestral spaces (eg projects such as The Brain Opera[4] (1996-2000) and Toy Symphony[5] (2000-2003).

---

[1] www.media.mit.edu/hyperins

[2] www.media.mit.edu/hyperins/projects/beatbugs.html

[3] www.media.mit.edu/hyperins

[4] brainop.media.mit.edu

For example, the Toy Symphony project was a series of educational workshops in which professional musicians worked alongside people of varying ages and abilities, which allowed for richer musical experiences via expert and peer-to-peer relationships. After each workshop, a performance in a major classical music venue with the children using the Hyperinstruments was conducted. In analysing the performances and to gain a better understanding of the expressive playing of the children using the Hyperinstruments, the MIT research group developed a real-time signal processing system, which analysed the expressive playing of an entire orchestra. What was interesting about this system was that it provided real-time feedback to the orchestra, which allowed players to further refine their sound during the performances (Jehan, Machover and Fabio 2002). In developing such a package (Hyperinstruments, educational workshops, live performance and analysis tool) the Hyperinstruments/Opera of the Future group created a multidimensional approach to supporting collaborative musical interaction, which it is anticipated could support participants with a lifelong interest in music.

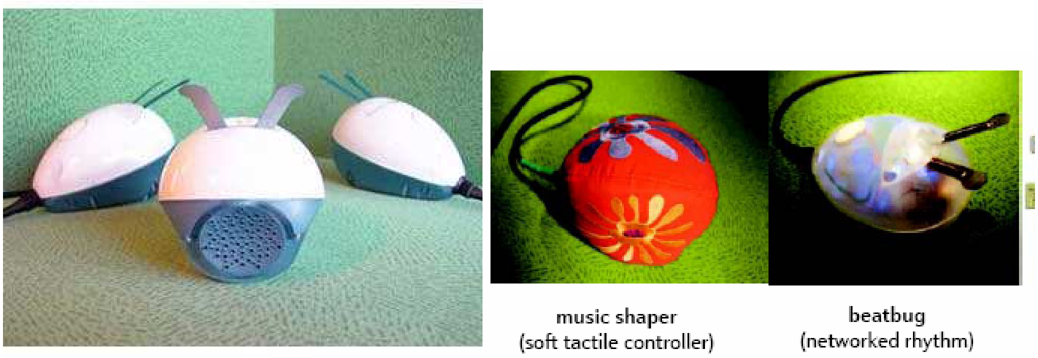

Image 1: Beatbug and Music Shaper images (image retrieved 23 June 2005 from www.media.mit.edu/hyperins/projects.html)

3.1.3 F@ust Music On-line (FMOL): La Fura dels Baus and Sergi Jordà, Barcelona, Spain

www.lafura.com/eng/fausto/infofau.htm

www.experimentaclub.com/data/sergi_jorda/0index.htm

F@ust Music On-line (FMOL) was part of the Catalan theatre group company's La Fura dels Baus show F@ust 3.0 (1997). The aim of the project was to develop a net-based virtual synthesiser and graphic interface, which allowed people with an interest in electronic acoustic music (professional, amateurs and newcomers) to compose and synthesise in real-time, over the internet. To support online synchronous communication, their design permitted users to listen to already existing pieces and either modify them or create their own new pieces. In enabling users to modify existing pieces an inbuilt user profile and preference system was created. The user profiling system allowed users to input their preferences (eg preferred musical genre, favourite instruments, musical training and level of expertise). The FMOL system then provided users with suggestions such as potential partners for collaboration or the most adequate musical pieces for participation in collective composition. After working on a suggested piece, the author evaluated the quality of the proposal. This information was stored in the system and taken into account in its next proposal. In this respect the system was constantly being tuned towards the preferences of the users by taking into account their feedback responses. Initially FMOL versions 1 and 2 discarded the implementation of real-time interaction between different users, mainly because of technical synchronisation restrictions,

[5] www.media.mit.edu/hyperins/projects/toysymphony.html

but this feature was implemented within the final versions, which allowed several players to share a common environment and improvise together (Jordà and Barbosa 2001).

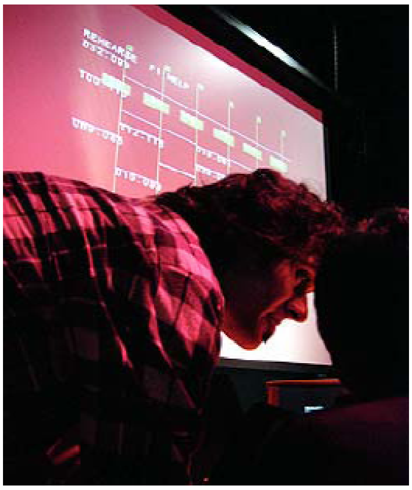

Image 2: Sergi Jordà with F@ust Music On-line (image retrieved 21 June 2005 from bulletin2.sigchi.org/archive/2002.2/nime.pdf)

In sum, the above projects highlight the potential of Interconnected Musical Interfaces (IMNs) for collaborative, joint music-making in real-time, synchronous, physical and virtual environments. This body of work raises key questions, such as:

1. Where do the new opportunities lie in using IMN and how can we build meaningful musical opportunities using them?
2. What kind of learning would they support and what kinds of learning contexts would we need to develop in order to successfully use them?

3.2 Mobile musical experiences

3.2.1 Jukola: The Mobile Bristol Centre

www.mobilebristol.com/jukebox.html

Jukola (O'Hara et al 2004) is an interactive 'shared MP3 jukebox' where customers in a café could democratically choose the music being played over the café's sound system. A public display was used to indicate which songs were nominated and voted for by members of the public via hand-held computers which were connected to a wireless network. Local bands and artists were also able to upload their songs into the system via the internet. The aim of the project was to explore how individuals could co-participate in the selection of music within a shared public space. The findings from the prototype trials showed that it supported playful competition and a sense of community.

Image 3: Jukola toolkit (image retrieved 23 June 2005 from www.mobilebristol.com/jukebox.html)

3.2.2 tunA: Media Lab Europe

web.media.mit.edu/~stefan/hc/projects/tuna/

Members of the Human Connectedness research group (Bassoli, Cullinan, Moore and Agamanolis 2003; Bassoli, Moore and Agamanolis 2004), which was formally based at Media Lab Europe, created tunA, a hand-held ad hoc radio device, which allowed users to share their music locally. tunA was installed on a series of iPaqs, hand-held personal computers, which allowed geographically distributed users the option to 'tune into' what other tunA players were listening to as well as share their play list, while on the move. According to the designers, possible applications for tunA could be in situations where people gather during the course of the day, for example, when riding the bus they could 'tune in' to other commuters and over time get to know them, or friends in a park could listen to the same music over their personal devices without disturbing others. What is interesting about tunA is that it maximises individuals' particular musical preferences, connecting them in an ad hoc manner, through music, to other people. Its application, as in the bus example, may connect people who normally would not operate in the same social sphere or who may not have the opportunity to meet each other via 'traditional' music sites (eg at a gig, through a fanzine etc or in a bus – refer to image 4).

Image 4: Potential uses of tunA (image retrieved 20 June 2005 from web.media.mit.edu/~stefan/hc/projects/tuna)

3.2.3 r-Music: The Computer Science Department, New Jersey, US

r-Music (pronounced 'our' music), stands for Resource Mediation by User-Supported Initiative in Communities and is a client-server architecture for sharing music (Wolz, Massimi and Tarn 2004). The client side of the server was installed in the personal digital music players of a group of people. When the individual members of the group met in a place where there was a high-quality sound system, the r-Music software on their devices was activated and collectively they could form a network. Users' personal music selections were transmitted through a wireless interface to the r-Music server, which stored each user's selections in a queue. As with Mobile Bristol's Jukola, a voting system was embedded within the software, with the most popular song being the one that got voted to be played over the sound system. The r-Music system builds on the tradition of the American high school idea of the 'sock hop' of the 1950s, where no one DJ or individual had control over what was played across the school sound system. Instead, each participant brought a song, which was added to an emerging co-created playlist.

3.2.4 Malleable Mobile Networks: Sony Computer Science Laboratory Paris

Tanaka (2004) has created a system (refer to Image 5) where mobile users can collaboratively re-create the songs they are hearing. As with the aforementioned projects his system also uses hand-held computers as musical devices. The computers are fitted with sensors which can read the user's bodily reactions. For example how intensely the user holds the device is translated via an algorithm into the brightness of the music; while the swing of the user's arm drives the tempo of the song through time-stretching techniques. As users move around a particular location, their positions are picked up via an ad hoc network and displayed as a graphic on the PDA's screen. Tanaka's prototype plays with the group's familiarity with the music and their play or interpretations of it, which they can manipulate via their body movements. The project marries our gestural and non-verbal responses to musical communication in a novel way, allowing users to collectively co-create and change a familiar piece of music, creating something new as they 'dance' their way around a particular location.

Image 5: Toolkit for Malleable Mobile Networks (image retrieved 23 June 2005 from www.csl.sony.fr/~atau/mobilemusic)

3.3 New musical interfaces for composition

3.3.1 DrumSteps: Trinity College Dublin, Ireland

www.cs.tcd.ie/crite/projects/creative-music/drumsteps/

DrumSteps is a screen-based virtual environment which allows the user to build sets of steps and produce percussion sounds by dropping balls down the steps. The number of horizontal steps controls the time between notes, while the height of each step controls accent/volume. Timbre is embodied in the ball and the full range of general MIDI percussion sounds are supported. Multiple ball/step combinations allow for multipart textures. Special or unusual sounds (cymbals etc) may be placed anywhere in the environment and triggered by a passing ball. The full range of time values are available, as are tools to enable repeats, loops, ostinatos etc. The system embodies the full range of rhythmic/percussive concepts including pulse, tempo, measure, timbre, texture, ostinato, syncopation, accent, anacrusis and so on.

The wormhole feature allows the ball to 'hyperjump' from one place to another in the score. Other features include trapdoors (allowing balls in one path to trigger events in another), a 'randomiser' icon (giving each ball multiple possible paths), and a 'ladder' icon (for subdivided note groups). Sub-menus allow the user to set the volume of each ball, set steps as accented or unaccented, and choose from a range of ladder options. Sub-groups of steps may be captured and stored in a favourites folder for later use.

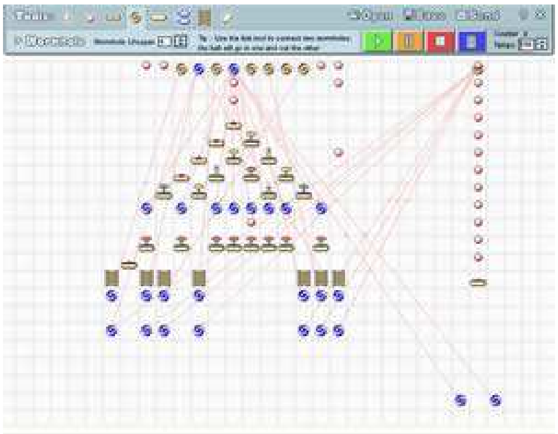

Image 6: DrumSteps screen grab (image retrieved 20 June 2005 from www.cs.tcd.ie/crite/projects/creative-music/drumsteps/index.html)

DrumSteps supports both synchronous and asynchronous collaborative composition. Geographically remote users may log on and view the same 'working space', where actions by any user are simultaneously transmitted to all other users in the group. Alternatively, a web-based environment for asynchronous collaboration has been developed, where users may upload and download compositions, enabling other users to access, modify and resubmit pieces.

DrumSteps represents an entirely novel approach to the teaching and learning of music. Traditional methodology assumes that novice users cannot engage in musical composition or construction without note-reading skills, prior training in musical rudiments and instrumental skills. In DrumSteps, users learn by experimentation, without the need for any prior musical training. The software engenders procedural thinking including iteration and debugging behaviours, and supports a wide variety of learning styles. Its effectiveness as a learning tool has been validated in a comprehensive set of school-based studies. Users were consistently observed to engage in high-level musical behaviour and reflection that would normally not be possible without note-reading skills or prior musical training.

DrumSteps was developed by Kevin Jennings, James Bligh and Conor McCarthy at the Centre for Research in IT in Education, Department of Computer Science, Trinity College Dublin, in collaboration with the Everyday Learning Group at Media Lab Europe, Dublin.

3.3.2 Hyperscore: Harmony Line and MIT, Massachusetts, US

www.harmonylinemusic.com

www.media.mit.edu/hyperins/ts-hyperscore

Hyperscore enables people of all ages to become composers just by drawing lines of various colours and shapes across a computer screen. You create music in a variety of styles simply by making short musical motifs and 'drawing' them onto a score with coloured pens. By adjusting the shape, length, colour and position of the lines you can readily produce melodies, choose harmonies, control tempo and more. You can play the piece, experiment with variations, and even print it in conventional notation.

Developed by researchers and musicians at the MIT Media Lab, Hyperscore unlocks creativity in children and adults alike, enabling novice users to compose sophisticated and original music. The tool has been trialled internationally (for an overview on the project refer to www.futurelab.org.uk/showcase/hyperscore/hyperscore.htm) and has been shown to support composition, arrangement and musical appreciation.

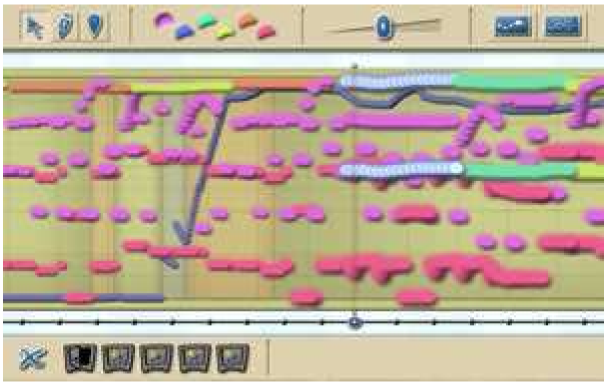

Image 7: Hyperscore screen grab

3.3.3 Ableton Live

www.ableton.com

Ableton Live is a loop-based software music sequencer for Macintosh and Windows. Version 5 has just been released this year (2005). Relative to other software sequencers Live is designed around the notion of being as much an instrument for live performances as a tool for composing and arranging. It is unique in offering a commercial real-time performance tool designed by performers for performers.

Image 8: Ableton screen grab (image retrieved 19 June 2005 from www.ableton.com)

3.3.4 Someth;ing: midiBalls, London, UK and Audiopad, MIT, US

www.somethingonline.org/txt/progress.html

www.jamespatten.com/audiopad/index.php

Someth;ing is a collective of designers and artists based in London. One of their many interactive projects is midiBalls, which is based on the mQube interactive table. This table allows you to track luminous objects on its surface and is similar to a project called Audiopad[6] developed by James Patten and Ben Recht while at MIT. Audiopad also tracks the positions of objects on a tabletop surface and converts their motion into music, via antennas that are inbuilt within the objects.

[6] www.jamespatten.com/audiopad/index.php

Projects such as Audiopad and midiBalls provide haptic, tangible interfaces through which players can touch, feel and control their musical compositions via the objects on the table. The difference between the projects is that Audiopad is considered by the developers as a compositional tool and allows fine-grained control over particular musical parameters, while midiBalls is a considered a game, where the aim is to keep the 'virtual balls' under control, as they fly around the screen, emitting various sounds as they bounce off each other and the physical elements on the table surface. Similar to Audiopad, the balls' sound parameters can be adjusted, creating an ambient soundscape. Currently Someth;ing are developing the mQube interface into a tangible arcade-style multiplayer pong game.

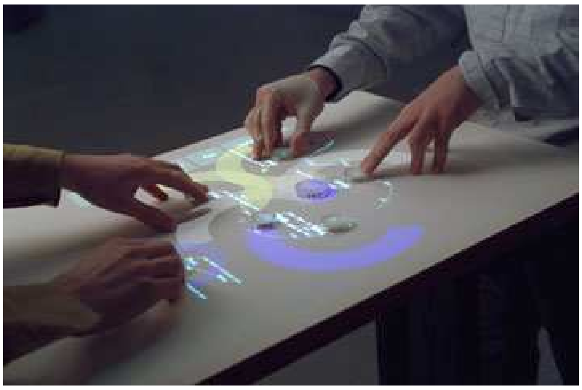

Image 9: Audiopad (image retrieved 20 June 2005 from www.jamespatten.com/audiopad)

DrumSteps, Hyperscore and Ableton Live show how software designed in teams with performers, computer scientists (Hyperscore, Ableton and Audiopad), music educators (DrumSteps) and artists (midiBalls) influence how compositional processes are supported and represented. Aside from Ableton, which repurposes more traditional music sequencing interfaces (eg Cubase, Logic), DrumSteps, Hyperscore, Audiopad and midiBalls are examples of new approaches to designing graphic musical interfaces. Designing new ways to represent the compositional and sound manipulation process is an important aspect as it influences the ease and fluidity of use and can lead to new musical understandings.

At Futurelab we believe that user-centred approaches to design, where expert and novice end-users are involved as early as possible in the process, is crucial to developing meaningful technologies. The above software tools raise a series of provocative questions not only about how we develop new digital music resources for the 21st century but also about the learning contexts, activities and resources we need to develop, for such devices to work effectively in learning settings.

3.4 Audio-visual music interfaces

3.4.1 Jungulator: I am the Mighty Jungulator and Futurelab, UK

Jungulator is the title of a self-generative tool that Bristol-based artists and programmers I am the Mighty Jungulator have been developing over the last four years, and which Futurelab is helping to turn into a usable resource for students. Drawing on features of current audio and visual systems, the software allows users to input, manipulate and output self-generative audio and visual material. In its basic form it has been used within community arts education and as a professional artistic-performance tool.

The main aim of the project is to extend and improve on the existing Jungulator software. Currently the audio and visual components of the Jungulator are separate; it is envisaged that this phase of development will support the integration of both the audio and visual generators, creating an interoperable tool that allows users (young people aged 14-17) to create their own unique arrangements. Integral to this phase is the development and evaluation of an appropriate user interface that facilitates young people's creativity when working with the Jungulator.

We envisage that the Jungulator's two main functions will be as:

- **A composition tool:** that allows users to input sound and visual sample files, carry out basic editing and manipulate the samples using various self-generative effects. We are also exploring the potential of enabling the tool to allow users to record and save their works.
- **A live performance tool:** where ad hoc audio-visual samples can be triggered and manipulated in a responsive, spontaneous fashion.

The project has been running at Futurelab since October 2004 and at the time of writing had just completed a four-week trial within a community arts centre in London. During this period a VJ and musician worked with young people to facilitate them to create AV compositions using the software. This phase of end user testing will feed into previous school and community sessions which were run over the R&D period. For updates on this project refer to www.futurelab.org.uk/showcase/jungulator/jungulator.htm.

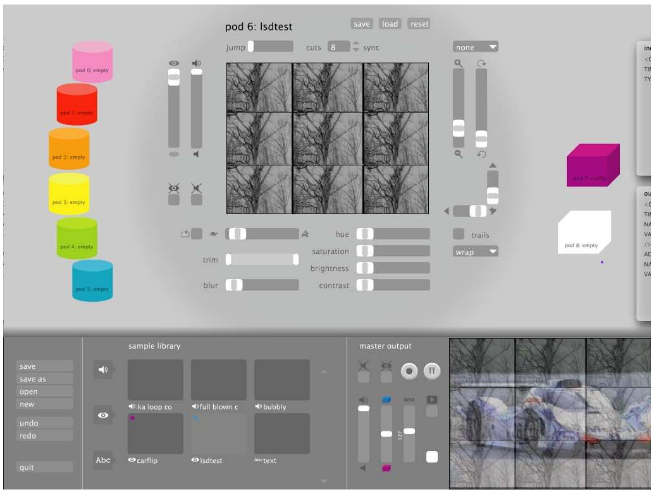

Image 10: New Jungulator interface

3.4.2 Jam-O-Whirl: Carnegie Mellon University, USA

Jam-O-World[7] is an interactive drumming table that allows groups of people with or without previous musical knowledge to share audio-visual experiences. It integrates interactive music elements with real-time video and computer graphics projections. Facilitating joint creativity, young people can simultaneously co-construct audiovisual tracks in real-time.

The Jam-O-World (refer to Image 11) was designed to bring people together to participate in collaborative musical gaming experiences in an immersive 3D environment. The experience combines multiplayer interactive games that encourage collaboration and cooperation, with turntable aesthetics. Each station around the Jam-O-Whirl table is a custom-built turntable device with an embedded electronic drum pad that together provides players with two methods of input. Each station is also equipped with a built-in directional speaker for audio feedback. The immersive aspects of the games are accentuated by 3D computer graphics that

[7] www.etc.cmu.edu/projects/jamoworld/history.htm

reflect the players' collective actions. These graphics are projected onto the tabletop and the walls of the exhibit space. Through specially designed musical gaming activities using Jam-O-Whirl, the designer found that it supported goal-oriented structures and free-form play and improvisation (Blaine and Forlines 2002).

Image 11: Using Jam-O-Whirl

Jungulator and Jam-O-Whirl demonstrate how developers have begun to merge composition, DJ and VJ packages within the same software. These technologies reflect on a long tradition where visuals have been used to enhance musical experiences. In relation to how they are used, the main difference between Jungulator and Jam-O-Whirl is that the latter is essentially a collaborative tool, whereas Jungulator can be used individually and in small groups (eg two people) around the computer. In addition these applications raise questions about how we appropriate new musical practices and provide motivating and engaging interfaces that support young people's cultures and interests. Additionally, the kinds of skills and relationships that such interfaces support raise a series of questions around our understanding of the creative process and challenge existing uses of computers within learning settings.

3.5 Custom-made performance instruments

The following is a small selection of work that individual researchers and performers have created. The work of STEIM[8] (Amsterdam, Netherlands) and of designers Ben Smith and David Bernard (Pointless Creations)[9] particularly demonstrates how performers and artists have begun to custom-build their own live performance tools, while the work of Dr Joe Paradiso (Co-Director, Things That Think Consortium and Director of the Responsive Environments Group, MIT) demonstrates how in working across multidisciplinary teams they have pushed the envelope of new musical interfaces.

3.5.1 The Hands: Michel Waisvisz (STEIM), The Netherlands

www.steim.org/steim

www.crackle.org/instruments.php

The Hands were used in concert for the first time in The Concertgebouw in Amsterdam in 1984 and since then have been continually refined as a live performance instrument. The instrument consists of a number of sensors and keys mounted on two small keyboards that are attached

[8] www.steim.org/steim

[9] www.pointlesscreations.co.uk

to the player's hands. The combination of many different sensors to capture the movements of the hands, the fingers and the arms is unique and makes The Hands one of the most refined musical MIDI-controllers.

Under the direction of Waisvisz, STEIM has become a leading international group which has explored the boundaries of new musical interfaces over the last two decades. For those interested in this area, their site www.steim.org/steim is a rich resource of links to others who are working in this area.

Image 12: Michel Waisvisz, The Hands (image retrieved 17 January 2006 from www.crackle.org)

3.5.2 Dance Shoes: MIT Lab, US

www.media.mit.edu/resenv/danceshoe.html

Dr Joseph A Paradiso is one of the leading researchers in the field of new musical interfaces; his personal home page is a rich source of research, design and theory in this field - web.media.mit.edu/~joep/. One novel project that Dr Paradiso and his team have created is Dance Shoes.

Dance Shoes is an instrumented pair of dancing sneakers. They allow the wearer to control sound and visual content via sensors that are embedded within the shoe. These sensors read parameters such as the pressure and bend of the sole, and by manipulating these variables the user can control the presentation of audio-visual content. The system has been used in several interactive dance performances and gives dancers intimate control over a dynamic musical stream which is mapped onto the shoe sensor signals via a complex rule base.

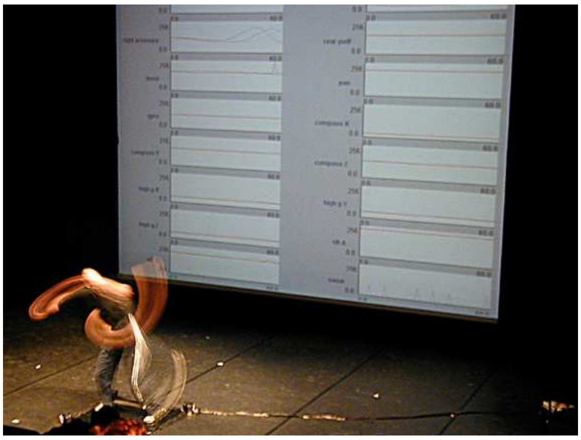

Image 13: Dance Shoes in action (image retrieved 19 June 2005 from www.media.mit.edu/resenv/danceshoe.html)

3.5.3 DigiCow: Ben Smith and David Bernard (Pointless Creations), Glasgow, Scotland

DigiCow is an innovative, digital hand drum (refer to Image 14) that combines traditional percussion skills with advanced ergonomics and up-to-date sound manipulations. Designed as a practical performance tool for both percussionists and electronic musicians, the instrument features sensitive playing surfaces, 500 CD-quality editable internal sounds, real-time sequencing and full MIDI specs enabling intuitive creation of a wide range of rhythmic soundscapes. Smith and Bernard's drum showcases how innovative design can be matched with real-time sequencing, to produce a new aesthetic.

Image 14: DigiCow

In the design of new music instruments, issues such as the level of control over the sound, the sound quality, the instrument's playability, potential for expression and interaction, and aesthetic design of the instrument are continuing concerns. Professional practitioners-designers, such as Waisvisz, Paradiso, Smith and Bernard are pushing the application of non-invasive, precision sensing technologies that demand real-time user interfaces, which allow micro, immediate and responsive control of their instruments. The work of these practitioners again demonstrates how professional performers, designers and researchers have come together to build instruments specific to their performing needs.

On the other side of the scale, designers of interfaces for the amateur musician and general public (eg Jam-O-Whirl, Toy Symphony) are pushing mapping techniques, pattern recognition, algorithmic composition and artificial intelligence, which is allowing for greater macro, real-time musical interaction and communication (eg the use of gesture and touch to create and manipulate complex sound streams). Generally work in this area tends to focus on collaboration and supporting social, interactive experiences.

Developments on the continuum from professional to general public musical interaction play off each other, each highlighting how through technological innovation and experimentation the traditional learning relationships and interactions between the musician-instrument-audience are changing and being challenged. Recognising the advancements in these areas provides a greater understanding of recent innovations and acknowledges how the advancements in both professional, novice and general public musical interfaces are providing new ways to interact and communicate via music.

3.6 Programming languages through which to develop new music software

Central to many of the above innovations are the applications of graphic programming languages such as Max/MSP, which have allowed performers to custom-build their own instruments. Such languages are often open source (ie the human readable code is available for anyone to see and modify), which has lead to wealth of innovation and experimentation. Programmes such as Max/MSP are becoming increasingly popular at university level, where music departments encourage students to develop their own interfaces, while programmes such as SuperCollider, Max/MSP are recommended by organisations like STEIM.

3.6.1 Max/MSP

Max/MSP is one of the leading software applications for interactive sound installations. It combines Max, for real-time control of interactive musical and multimedia applications through MIDI, on top of which sits MSP[10] (Cycling '74[11], USA). MSP is a large set of Max audio processing objects for real-time analysis, synthesis and processing of audio signals. Over Max/MSP sits Jitter[12], which is a matrix set of data processing objects for video and 3D graphics. Jitter extends Max/MSP functionality by providing the means to generate and manipulate matrix data, that is data represented in numerical forms (eg video and still images, 3D geometry as well as text, spreadsheet data, particle systems and audio).

Max/MSP and Jitter have been used in the current Futurelab music project Jungulator as the means to create in real-time video processing, custom effects and audio-visual interaction.

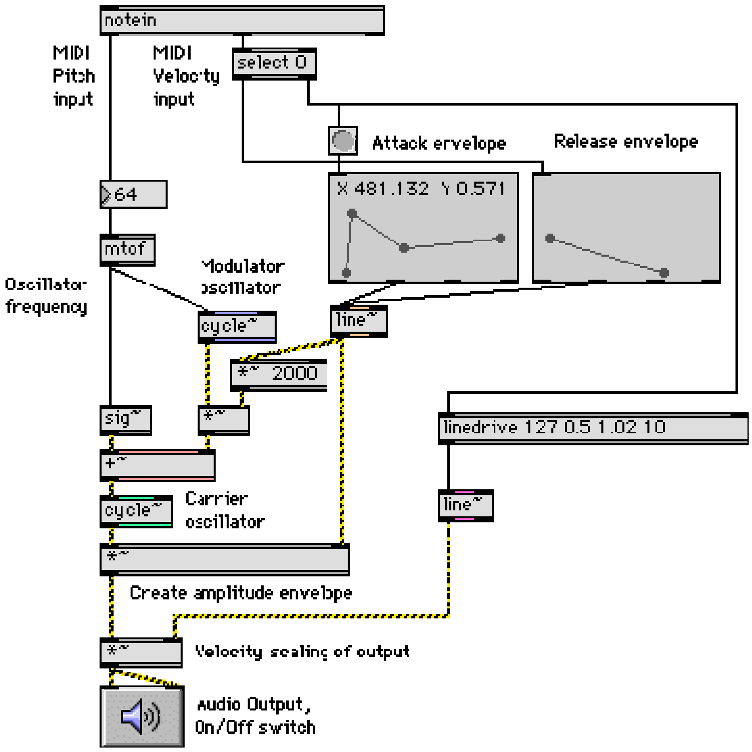

Image 15: Typical MAX/MSP interface

---

10 MSP is developed by Cycling '74 and is based on ideas implemented in IRCAM's previous real-time DSP environment, FTS

11 www.cycling74.com

12 www.cycling74.com/products/jitter.html

3.6.2 SuperCollider

SuperCollider is an environment and programming language for real-time audio synthesis. You can write programs to generate or process sound in real-time or non-real-time. SuperCollider can be controlled by MIDI, the mouse, Wacom graphics tablet, and over a network via Open Sound Control.

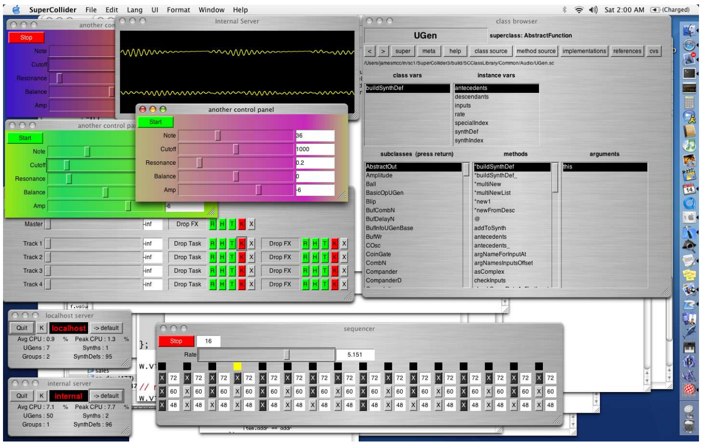

Image 16: SuperCollider screen grab

It is important to realise that underlying many of the aforementioned innovations is the story of open source tools, which enable users to freely modify code and adapt it to build new instruments. In addition graphic program languages such as Max/MSP allow novice programmers entry into a world where they can start to build custom-made instruments. In thinking about future scenarios for learning in music technology, both open source and proprietary languages and programmes have played an important role. Providing young people with the skills to manipulate these languages, provides them with the building blocks from which they can custom-make their own tools and develop new ideas.

4. WAYS FORWARD

Many of the aforementioned 'snapshot' projects crossed over into home, school and community applications. Each section – mobile music experiences, new musical and audio-visual interfaces, custom-made performance tools and programming languages - demonstrated the potential of new technologies for social, collaborative and individual music expression. In discussing these projects during the workshop participants had an opportunity to share their knowledge and comment on how such innovations could be used within educational contexts.

In considering future 2015 scenarios, participants brainstormed ideas where learners traversed seamlessly between live musical events in real and virtual worlds. On their journeys learners had opportunities to make new musical connections, as they were exposed to different styles and genres. Augmenting these experiences new, 3D, virtual technologies provided learners with forensic-like insight into the nuances of professional musicians' skills and their relationship with their instruments. Such experiences allowed for a greater understanding of the sensitive, expressive skills required by professional musicians.

On the street, hand-held musical interfaces allowed for everyday events to be sampled, shared and distributed across networks, while tangible and tactile interfaces ensured that music is accessible to for all ages and abilities, with more complex interfaces that could provide experienced musicians with new avenues of exploration and play. These visions were sketched by a storyboard artist and translated into 'posters' which have been distributed to thousands of schools across the UK. If you are interested in receiving the Music Innovations poster please e-mail innovations.workshops@futurelab.org.uk.

What these visions capture is a world where our musical identities are extended, negotiated and re-constructed via mobile and personal devices, in on- and offline environments. Such scenarios empower us to co-create our own musical compositions, publicly share them and engage in new musical ways with our surroundings. This world requires technical skills, confidence in moving between real and virtual worlds and knowledge of working across networks. It also requires large, accessible databases, secure yet flexible networks and importantly a new vision for how and where we learn and the tools, materials and resources necessary for this happen.

This world is slowly being built and underlies many of the visions articulated across the Innovations Workshops series. However currently technological innovation and case studies prototypes are ahead of policy and educational practice. Given the current personalised learning (Miliband 2004; Green, Facer, Rudd, Dillon and Humphreys 2005) and Buildings Schools for the Future[13] agendas, the visions brainstormed and discussed within this workshop are important indicators of how these agendas can be achieved not only within subject areas such as music, but across the curriculum.

6. REFERENCES

Bassoli, A, Cullinan, C, Moore, J and Agamanolis, S (2003, 12-13 October). tunA: a mobile music experience to foster local interactions. Paper presented at the 5th International Conference on Ubiquitous Computing, Seattle

Bassoli, A, Moore, J and Agamanolis, S (2004, September). tunA: synchronised music-sharing on handheld devices. Paper presented at the 6th International Conference on Ubiquitous Computing, Nottingham

Berliner, P (1994). Thinking in Jazz: The Infinite Art of Improvisation. Chicago: Chicago University Press

Bischoff, J, Gold, R and Horton, J (1978). Microcomputer network music. Computer Music Journal, 2(3), 24-29

Blaine, T and Forlines, C (2002). JAM-O-WORLD: evolution of the Jam-O-Drum multi-player musical controller into the Jam-O-Whirl gaming interface. Paper presented at the Conference on New Instruments for Musical Expression (NIME-02), Media Lab, Dublin, Ireland

Brown, JS, Collins, A and Duguid, P (1989). Situated cognition and the culture of learning. Educational Researcher, 18(1), 32-42

Chestermann, J and Lipman, A (1988). The Electronic Privates: DIY Crimes of the Century. London: Routledge

Cohen, S (1991). Rock Culture In Liverpool. Oxford: Oxford University Press

Cope, P (2001). Informal learning of musical instruments: the importance of social context. Paper presented at the 2nd International Research in Music Education Conference, University of Exeter

[13] www.bsf.gov.uk

Cox, C and Warner, D (2004). Audio Culture Readings in Modern Music. London, New York: Continuum Publishing

Dillon, T (2003). Collaborating and creating using music technologies. International Journal of Educational Research, 39(8), 893-897

Dillon, T (2004). It's in the mix baby: exploring how meaning is created within music technology collaborations. In D Miell and K Littleton (eds), Collaborative Creativity, Contemporary Perspectives. London: Free Association Books

Dillon, T (forthcoming). Exploring young people's collaborative and creative processes using keyboard and computer based music technologies in formal and non-formal settings. Unpublished PhD, The Open University, Milton Keynes

Dillon, T, Joiner, R and Miell, D (2001). An investigation into music technology practices. Paper presented at the RIME, Research in Music Education, University of Exeter

du Gay, P, Hall, S, James, L, Mackay, H and Negus, K (1997). Doing Cultural Studies: The Story of the Sony Walkman. London: Sage Publications

Duckworth, W (1999). Making music on the web. Leonardo Music Journal, 9, 13–17

Fessenden (2002). Peer-to-peer Technology: Analysis of Contributory Infringement and Fair Use. Retrieved 4 January 2005, from www.idea.piercelaw.edu/articles/42/42_3/3.Fressenden.pdf

Folkestad, G, Hargreaves, DJ and Lindström, B (1998). Compositional strategies in computer-based music-making. British Journal of Music Education, 15(1), 83-87

Goetz, T (November 2004). Sample the Future. Wired, 181-183

Green, H, Facer, K, Rudd, T, Dillon, P and Humphreys, P (2005). Personalisation and Digital Technologies. Bristol: Futurelab.
www.futurelab.org.uk/research/personalisation/report_01.htm
Retrieved 17 January 2006

Green, L (1998). How Popular Musicians Learn - A Way Ahead for Music Education. Aldershot: Ashgate

Gresham-Lancaster, S (1998). The aesthetics and history of the hub: the effects of changing technology on network computer music. Leonardo Music Journal, 8, 39-44

Hebdige, D (1993). Cut 'n' Mix: Culture, Identity and Caribbean Music. London: Routledge

Jehan, T, Machover, T and Fabio, M (2002). Sparkler: an audio-driven interactive live computer performance for symphony orchestra. Paper presented at the International Computer Music Conference, Göteborg, Sweden

Jordà, S and Barbosa, A (2001). Computer Supported Cooperative Music: Overview of Research Work and Projects at the Audio Visual Institute – UPF. Retrieved 7 January 2005, from www.iua.upf.es/mtg/publications/mosart2001-jorda.pdf

Keys to Imagination ICT in Art Education. (2003). Retrieved 16 April 2005, from www.artscouncil.org.uk/information/publication_detail.php?sid=9&id=361&page=2

Kratus, J (1991a). Characterization of the compositional strategies used by children to compose a melody. Canadian Journal of Research in Music Education. (33), 95-103

Latta, C (1991). Notes from the NetJam Project. Leonardo Music Journal, 103–105

Lave, J and Wegner, E (1991). Situated Learning: Legitimate Peripheral Participation. Cambridge, England: Cambridge University Press

MacDonald, RAR, Hargreaves, DJ and Miell, D (eds) (2002). Musical Identities. Oxford: Oxford University Press

McCarty, M (1997). Irish music education and Irish identity: a concept revisited. Oideas, 45(Autumn), 5-22

McCarty, M (1999). Passing it On: The Transmission of Music in Irish Culture. Cork: Cork University Press

Mellor, L (2001). Computer based composition in the primary school: an investigation of children's composition responses using Dance eJay. Paper presented at the RIME, Research in Music Education, University of Exeter

Miliband, D (2004). Choice and voice in personalised learning. Presentation given at a DfES Innovation Unit/Demos/OECD conference, Personalising Education: The Future of Public Sector Reform, 18 May 2004, London

Mills, J and Murray, A (2000). Music technology inspected: good teaching in Key Stage 3. British Journal of Music Education, 17(2), 157-181

Murray, A (1997). The Music IT Support Project. Available at the Becta website, www.becta.org.uk

Oberholzer, F and Strumpf, K (2004). The Effect of File Sharing on Record Sales and Empirical Analysis. Retrieved 10 December 2004, from www.nber.org/~confer/2004/URCs04/felix.pdf

Oehrle, E (1991). An introduction to African views of music making. Journal of Aesthetic Education, 25(3), 163-173

Ofsted (2002a). ICT in Schools - Implementation of Government Initiatives - Secondary - Music. London: Office for Standards in Education (Ofsted)

Ofsted (2002b). ICT in Schools: Effect of Government Initiatives - Secondary Art and Design. London: Office for Standards in Education (Ofsted)

Ofsted (2004). ICT in Schools 2004: the Impact of Government Initiatives: Secondary Music. London: Office for Standards in Education (Ofsted)

O'Hara, K, Lipson, M, Jansen, M, Unger, A, Jeffires, H and Macer, P (2004). Jukola: Democratic Music Choice in a Public Space. Paper presented at the Designing Interactive System (DIS), Massachusetts, USA

Pitts, A and Kwami, RM (2002). Raising students' performance in music composition through the use of information and communications technology (ICT): a survey of secondary schools in England. British Journal of Music Education, 19(1), 61-71

Plumleigh, M (1990). Digital audio tape: new fuel stokes the smouldering home taping fire. UCLA Law Review, 34, 733-776

Quantum (2004). Understanding CD Burning and Internet File Sharing and its Impact on the Australian Music Industry. Albert Park, Victoria, AU: ARIA, Australian Recording Industry Association

Rogers, K (1997). Resourcing music technology in secondary schools. British Journal of Music Education, 14(2), 129 -136

Rogoff, B (1990). Apprenticeship in Thinking: Cognitive Development in Social Context

Rosenbrock, A (2002). The composition process in pop and rock bands: musical creativity in groups. Paper presented at the 10th European Society for the Cognitive Sciences of Music, Musical Creativity, University of Leige, Belgium

Salaman, W (1997). Keyboards in schools. British Journal of Music Education, 14(2), 143-149

Seddon, F and O'Neill, SA (2001). An evaluation study of computer-based compositions by children with and without prior experienced of formal instrumental music tuition. Psychology of Music, 29(1), 4-19

Sefton-Green, J (ed) (1999). Creativity, Young People and New Technologies: the Challenge of Digital Arts. London: Routledge

Tanaka, A (2004, 7-10 September). Malleable mobile music. Paper presented at the 6th International Conference on Ubiquitous Computing, Nottingham, UK

Toynbee, J (2001). Creating Problems: Social Authorship, Copyright and the Production of Culture. Milton Keynes, UK: Pavis Centrex for Social and Cultural Research, Open University

Toynbee, J (2003). Music, culture and creativity. In R Middleton, M Clayton and T Herbert (eds), The Cultural Study of Music. Maidenhead, Berkshire: The Open University Press

Troop, D (2004). Haunted Weather: Music, Silence and Memory. London: Serpent Tail

Weinberg, G (2002a). The aesthetics, history, and future challenges of interconnected music networks. Paper presented at the International Computer Music Conference, Göteborg, Sweden

Weinberg, G (2002b). Playpens, fireflies and squeezables - new musical instruments for bridging the thoughtful and the joyful. Leonardo Music Journal

Weinberg, G, Aimi, R and Jennings, K (2002). The Beatbug Network - a rhythmic system for interdependent group collaboration. Paper presented at the New Instruments for Musical Expression (NIME), Dublin, Ireland

Weinberg, G, Lackner, T and Jay, J (2000). The Musical Fireflies - learning about mathematical patterns in music through expression and play. Paper presented at the Colloquium on Musical Informatics, A'quila, Italy

Wolz, U, Massimi, M and Tarn, E (2004, 13-15 September). r-Music, a collaborative music DJ for ad hoc networks. Paper presented at the 4th International Conference on Web Delivering of Music (Wedelmusic), Universitat Pompeu Fibra, Barcelona, Spain