Hand2Hand and Dot2Dot: developing instruments for the music classroom

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Abstract
This article explores the process of developing new software musical instruments for use in the Key Stage 2 (primary pupils aged between 7 and 11 years) and Key Stage 3 (secondary pupils aged between 11 and 14 years) music classrooms. It considers the process of instrument design, educational application and use through case studies drawn from the project’s two distinct stages. It reflects on aspects related to instrument design, associated instrumental technique and learner motivation. It highlights the concept of infra-instruments as a potential way forward for further research and development, but emphasizes that a careful exploration of the performance ecology of the classroom (or other contexts for learning) is vital if musical performance tools are going to have the desired educational and musical impact.

Introduction
This article explores the process of developing two new musical instruments for use in the Key Stage 2 (primary pupils aged between 7 and 11 years) and Key Stage 3 (secondary pupils aged between 11 and 14 years) music classrooms. The development of these instruments took place in two main stages. Stage 1 was funded by UCan.tv, a not-for-profit company, and resulted in an instrument called Hand2Hand (UCan.tv 2007). This instrument utilized four traditional Playstation 2 games controllers, a USB interface that allowed these to be connected to a standard PC running Windows XP, and the specially designed software instrument. This instrument allowed users of the software to play four separate instruments in a quartet. These instruments included a melodic, harmonic, bass and rhythm part.

The second stage of the project was supported by an Enterprise Fellowship that was awarded to the author through his university employment. This Fellowship facilitated the development of Hand2Hand for the specific purpose of introducing staff notation to Key Stage 2 pupils through a variety of interactive games that made use of the Hand2Hand programme code. This new application of Hand2Hand was named Dot2Dot, a deliberate play on the famous children’s activity of creating a picture by connecting dots together and, of course, musicians’ use of the term ‘dots’ to describe pieces of staff notation.

Throughout both stages of the project trials of the software were conducted in primary and secondary schools. This article will explore the process of instrument design, educational application and use informed by...
user feedback through case studies that were drawn from the project stages (described above). It will consider the development of a bespoke instrument for music educational settings and put forward some ideas for further research. But before doing this, two important contexts for these developments will be outlined.

The educational context
The uses of information and communication technologies (ICT) for music education in primary and secondary schools are well established. Within music education at Key Stage 2 (for pupils aged 7–11 years) and Key Stage 3 (for pupils aged 11–14 years) the use of a range of music technology is a legislative requirement (QCA 2008). However, recent research conducted on behalf of the Training and Development Agency (TDA) had demonstrated that many of these uses of technology are conservative in their nature and practice, seeking to reinforce traditional approaches to musical knowledge and learning (Teacher Training Resource Bank 2009). A recent national survey conducted by the author (Savage 2009) on behalf of a major manufacturer of music technology found that computer software such as Sibelius and Cubase dominated music teaching from Key Stage 3 onwards, and that the individualized nature of composition tasks at Key Stage 4 (i.e. pupils aged between 14 and 16 years and taking a General Certificate of Secondary Education in Music) became the main location for ICT usage at this level. This preoccupation with notation and sequencing software can be traced back through the last decade by analysis of data provided by the Fischer Family Trust (2004).

The recent introduction of the new Key Stage 3 National Curriculum signals an important change. Whereas previous curriculum orders emphasized the use of ICT as a compositional tool, the new National Curriculum for Music places a greater emphasis on the application of ICT to help pupils learn the processes of musical performance. It states that the curriculum should provide opportunities for pupils to ‘develop individual performance skills, both vocal and instrumental, including the use of music technology’ (QCA 2008). Although this may not sound revolutionary, this sentence has focused the minds of music educators across the United Kingdom, and new approaches are being considered and developed in a number of areas (Ashworth 2009).

The technological context
In the world outside formal education, the range of technologies that are exploiting musical performance as an opportunity for game design and content are moving forwards rapidly. Recent software packages such as Wii Music (Nintendo 2009b), Guitar Hero (Activision Publishing Inc. 2009) and SingStar (Sony 2009) all bring musical performance into the home environment and encourage users to play a range of virtual interfaces through performance devices, often offering real-time feedback to users about their progress. Some of these manufacturers have also recognized the potential of an educational market for their products. Nintendo have recently collaborated with the National Association for Music Education, the United States of America’s largest association for music education, in trialling Wii Music with a large number of high schools across the country (Nintendo 2009a, 2009c).
More informally, it has been interesting to note through several music teacher forums in the United Kingdom, such as the Times Educational Supplement and the TDA-funded Teaching Music website, how these pieces of software, and their associated hardware, are beginning to impact music education (e.g. TES 2009; TDA 2009).

Within the more experimental, electroacoustic field there is a yearly conference devoted to ‘new interfaces for musical expression’ (NIME 2009). Papers drawn from recent NIME conferences presented a range of important themes for consideration in designing a new instrument for the classroom context. As will become apparent, these papers became a particularly important source of knowledge and understanding for the analysis of the two experimental classroom instruments discussed below.

Research methodology and methods
In the next part of this article, the two related instruments will be presented through two, short case studies. Each case study involved a design and trial stage. During the design stages, the author and the programmer met regularly to plan and discuss developments. Minutes of these meetings formed part of the case record. The author kept an e-journal documenting developments on his blog. During the trial stages, documentary evidence (including video, photographic and audio recordings) was collected from the two trial sites. Evaluation data from the pupils using the software were also collected through simple questionnaires (completed during the lessons) and short interviews with selected pupils.

Following a brief presentation of each case study below, an analysis will be undertaken that draws on selected pieces of data collected through the design and trial stages of each instrument.

Case Study 1: Hand2Hand

Design stage
Hand2hand was UCan.tv’s first attempt to produce a performance instrument for the classroom setting. The instrument was controlled by a standard Playstation 2 controller (equipped with fourteen buttons and two gyroscopes) attached to the PC through commercially available USB – Playstation controller interfaces.

As can be seen from Figure 1, the instrument is broken into four main parts (chords, lead, bass and percussion). Each part will be briefly introduced.

Chords
The chord part allows the user to select four main chords with any chromatic root note. These are then played by pressing the triangle, circle, square and cross buttons on the right of the controller. Each chord can be designated as major, minor, 7th, major 7th, minor 7th, suspended 2nd or 4th. Users can choose between 37 different sounds for their chord part, increase or decrease the octave at which the chord is played, add echo and reverberation, and control the overall volume of the part.

Lead
The lead part accesses the same bank of 37 sounds as the chord part. Users can select any key to play within. They choose a particular scale...

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type to play with, including major, harmonic or melodic minor, major and minor pentatonic, chromatic or blues scales. They can also adjust the octave at which the scale plays, add echo and reverberation, and control the overall volume of their part. Scales are played by pressing the various controller buttons in order, starting (lowest pitch first) with the four graphic symbols (triangle, circle, cross and square) and moving onto the L1, R1, L2 and R2 buttons. Pressing down the left gyroscope allowed the player to shift the pitch up one octave.

**Bass**

The bass part is similar in functionality to the lead instrument. The only difference is that the user can select from eight bass sounds from a new sound bank within the software.

**Percussion**

The percussion part allows users to choose four sounds from a bank of 21 drum and percussion sounds. These sounds are assigned to, and played by pressing, the triangle, circle, square and cross buttons on the right hand side of the controller. Echo and reverberation can be applied to the part in a similar way to the other instruments. Each part can be assigned an individual volume setting, as well as the overall volume for the part (in line with other parts).

Additionally, the percussion part has the option of creating a simple four-bar step sequence in either 4/4 or 3/4 time using sixteenth notes. Once completed, these pre-composed patterns are played by holding down...
the L1, R1, L2 and R2 buttons. The overall tempo of the beat is selected by a slider at the top of the screen.

The instrument allowed the user(s) to play melodies, bass lines and simple rhythmic patterns on a four-part drum kit and chords.

As well as the four instrument parts, the software has a number of global features. First, users can save up to eight patches for the four instrumental parts that they are playing. This can allow them to create variations to instrumentation, chord structures, scale choices, etc. and change them quickly within a piece. These patches are saved together as a ‘preset’ bank that can be loaded into the instrument. This was seen as important, particularly as a way to encourage pupils to work with the instrument over a number of weeks. Finally, the grey, ghostly images of the four controllers on the right hand side of the software light up when controller data are being received. This allows users (and teachers) a quick way to check connectivity.

**Trial stage**

This instrument was trialled at Sandbach High School for Girls with a group of 30 pupils in Year 8. In the first lesson, pupils were given a 3-minute introduction to the instrument, including a demonstration of each instrument part. Pupils were then given simple scores for two pieces of music in four parts. They were asked to learn these together in groups of four. An example of one of the parts can be seen in Figure 2.

The key point in giving a structured activity such as this was to encourage pupils to explore the instrument, to check for any technical difficulties (either with the software or the hardware) and observe how pupils worked as a group with the software (Figure 3).

In the second lesson with Hand2Hand, pupils were given an open-ended compositional task. They were asked to create a piece of music with the Hand2Hand instrument that lasted between 1 and 2 minutes. As an incentive, pupils were informed that the pupils who created the ‘best’ composition (as judged by their regular classroom teacher) would be given vouchers to spend in the local HMV music store.

The observations and findings related to the design and trial of this instrument will be discussed in the analysis below.

**Figure 2.**

Hand2Hand and Dot2Dot
Case Study 2: Dot2Dot
Dot2Dot applied the ideas and basic functionality of Hand2Hand to the Key Stage 2 (primary, aged between 7 and 11 years) classroom. In particular, it aimed to develop an interesting way to introduce staff notation to these pupils through the use of the Playstation symbols (circle, square, triangle and cross). The decision to focus on applying Hand2Hand to the introduction of staff notation to pupils at Key Stage 2 was taken after reflecting on discussions held with teachers and a small group of students undertaking a course on initial teacher education at the author’s university. Through this discussion, it became apparent that for many teachers the whole concept of Hand2Hand was a considerable departure from their current practice. As such, the design team made the pragmatic decision to focus on an area of common musical practice (i.e. the introduction of basic staff notation within Key Stage 2), and to consider what impact a new tool could make within this.

As with Hand2Hand, the case study will present aspects of Dot2Dot’s design before discussing the trial held at a primary school in the north west of England. Dot2Dot’s development was funded through the author’s receipt of an Enterprise Fellowship from the Manchester Metropolitan University.

Design stage
Dot2Dot was programmed by Chris Bowes, the same programmer who UCan.tv worked with to produce Hand2Hand. Bowes was an integral part of the software’s design. Regular meetings between the author and Bowes discussed key elements of the software, how they would be sequenced together, and what pupils might learn from working with the game.

Dot2Dot is predominantly a solo-player game. As well as the software, users required a single Playstation controller and USB interface (similar to
Hand2Hand and Dot2Dot. The final trial version contained three main activities: Song, Pattern and Follow (see Figure 4).

**Song**

Song allows the user to play along with three songs, using the Playstation controller as the instrumental interface (in a similar way to Hand2Hand’s ‘Lead’ part, described above). Each of the three songs can be played in ‘easy’ or ‘hard’ versions. This setting affected how the staff notation within the performance would be displayed. ‘Easy’ songs had the symbolic element of the Playstation controller button embedded within the note-head as a guide for the user (see Figure 5).
‘Hard’ versions of the songs omitted the symbolic element of the Playstation controller button, leaving the user with what looks like traditional staff notation (see Figure 6).

Each song is accompanied by a specially constructed MIDI file accompaniment. There is no tempo adjustment. Users receive immediate feedback as their performance progresses, with ticks appearing for correct notes and ‘miss’ appearing when a wrong (or no) note is played. At the end of the performance, users get a final score for the accuracy of their performance (see Figure 7).
Within the ‘Pattern’ game, users play a listen and copy game. A number of patterns of increasing difficulty are played to the user that they are required to immediately copy. As with ‘Song’, the user can try an ‘easy’ or ‘hard’ mode. In ‘easy’ mode, traditional staff notation is replaced by a symbolic element of the Playstation controller button placed at the appropriate point of the score (see Figure 8).

In the ‘hard’ mode, these symbols disappear, leaving the user with just traditional staff notation (see Figure 9).

Figure 8.

Pattern

Figure 9.
Finally, the ‘Follow’ mode allows users to enter their own patterns for a two-player version of ‘Pattern’. Once one user has inputted four four-note patterns, these patterns are then used to test the other player (see Figure 10). As with the other games within Dot2Dot, there is an ‘easy’ and ‘hard’ setting for this activity.

**Trial stage**

Dot2Dot was trialled at St John’s Church of England Primary School in Sandbach Heath during December 2008. Due to the small number of computers available in the school library, a Year 5 class was divided into two halves, with each half working through approximately one hour’s worth of activities with the software (Figure 11).

Pupils were introduced to the software through a short, 5-minute presentation. The key elements of playing along with the songs and the copying games were demonstrated. After an extended period of play with the software, a short ‘concert’ of performances with the software was held, with pupils being given the opportunity to talk about their work with the software whilst being recorded on video. This proved particularly useful for our subsequent evaluation of the trial.

**Analysis**

The analysis of these case studies will be structured under five main headings. These headings emerged during a process of reflection on the data collected during the design and trial stages of each study. Each part of the analysis is considered in light of recent research into the design of new instruments for musical expression.
1. Instrument design

Instrument design is fundamental to this work. Even at the pre-design phase, deliberate choices about the hardware and performance context for these instruments affected their design in terms of functionality and resulting musical opportunities. Central to these deliberations was the choice to use a Playstation controller as the performance instrument. Blaine’s research (2005) investigates a number of alternative controllers that have made an impact in the field of interactive entertainment. When she talks about learning, she makes an interesting comparison to computer game design:

Musical instruments must strike the right balance between challenge, frustration and boredom: devices that are too simple tend not to provide rich experiences, and devices that are too complex alienate the user before their richness can be extracted from them. In game design, these same principles or ‘learnability’ are the fundamental principles of level design used to build an interest curve to engage players.

(Blaine 2005: 28)

Interestingly, in a paper that is focussed on interactive entertainment devices, Blaine goes on to make a timely application to those of us engaged in education:

It would appear that alternate controllers have finally achieved status as a critical component of game play. This puts the NIME community in a unique
position to raise the bar as to the quality and range of experiences, devices, and the expressive capabilities they inspire, particularly as it relates to music creation and education.

(Blaine 2005: 32)

We were pleased to note that pupils responded well to the challenge of these two instruments. Every session was characterized by significant levels of enthusiasm and motivation. Verbal feedback through class discussion or individual interviews was similarly positive in this respect.

Blaine’s point about challenge, frustration and boredom is vital for teachers though (Blaine 2005: 28). In choosing instruments to use within the classroom, these issues are high up on their list of priorities. A recent survey of music technologies within high schools (Savage 2009) has shown an over-reliance on commercial software packages that are far away from pupils’ wider experiences of technology. It appears that the choice to use a technology that was relevant, well known and understood by pupils became a key or hook that encouraged them to delve more deeply into the potential of the instrument itself.

Surprisingly, the functionality of the controllers and USB interfaces was good. There was no need to configure them within the operating software. They plugged and played. Future iterations of the software will probably preclude the use of the USB interface in favour of a Playstation controller with a direct USB connection.

2. Instrument technique

The issue of instrument design allies itself closely with the second consideration, instrument technique. Many of the pupils using Hand2Hand and Dot2Dot found them challenging in the first instance. But, with practice over a short period of time, they showed big improvements. The differentiated teaching framework that was used with Hand2Hand can be considered as a conventional approach (i.e. the adoption of two notated performance pieces of increasing difficult leading to an open-ended compositional task). The adoption of ‘easy’ and ‘hard’ settings within Dot2Dot allowed pupils a greater degree of freedom as to what level they entered the software. Many ignored the ‘easy’ setting and jumped straight to the ‘harder’ pieces and copying games. In evaluative data, several pupils commented on the need to tailor the activities further to encourage this degree of ownership. Examples included providing a variable tempo control for the Dot2Dot pieces and more difficult, two-part (two-player) patterns for the copying game.

Oore’s work (2005) was informative here. His concern is with ‘technique and how this is learnt by aspiring instrumentalists when faced with a new instrument to learn’. His research explores what one actually does when beginning to learn to play a complex new digital instrument (Oore 2005: 60). This relates back to the discussion about instrument design and the choice of a familiar interface. It was interesting to note that those pupils who made the most progress with the Dot2Dot instrument were those who professed to be keen computer gamers. The best (i.e. most accurate) performance of the hardest piece was from a male pupil who had no experience of playing a traditional musical instrument but who, in his words, loved ‘playing any kind of computer game’.

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3. Learning and motivation

Establishing an initial hook to engage pupils’ interest is one thing, but sustaining it over a longer period and building a sense of intrinsic motivation within a learning activity or sequence of learning activities is something else entirely. Oore’s observation that ‘if an instrument were designed to be easy to master it would quite possibly not be that interesting to play or to listen to once the initial novelty of the instrument or controller had worn off’ (Oore 2005: 60) is crucial here. This led us to reflect briefly on learning and motivation.

Oore analyses a range of general concepts that, he suggests, might apply to the learning of a new instrument. These are couched under a statement that ‘the individuality of a musician is manifest in their learning process as much as in their performance’ (Oore 2005: 61). Whilst this might be conceptually true, it is not a lot of help for educators who, despite recent debates in the personalization of learning through informal pedagogic approaches (e.g. Musical Futures 2009), generally have to make certain presumptions about the commonalities in the sequence of learning and prioritize knowledge accordingly. The major factor in our consideration was the degree to which an educational instrumental designer should leave that to chance or build it into the instrument design. The case studies differed in this respect. Hand2Hand is, in this sense, a generic instrument that needs the teacher to apply and contextualize it within a learning environment. Dot2Dot, on the other hand, has a particular purpose and function that is easily understood. It also relates clearly to aspects of traditional musical knowledge and theory, which, for some teachers at least, makes it instantly more understandable and accessible. Within the classroom setting, it is still the case that the teacher is the arbiter of many important decisions related to the choice of learning tools, contexts and sequences. Many are reluctant to relinquish this. Adopting a tool from the gaming community had an initial impact on pupil motivation, but we are not naïve enough to presume that this will last long. Further research about how such a tool can be adopted and enculturated over a longer period of time will be needed.

4. Infra-instruments

What exactly are Hand2Hand and Dot2Dot? Bowers and Archer (2005) categorize new performance instruments under various categories, including meta, hyper and cyber-instruments. These types of instruments, they purport, provide a rich, interactive capability, engender complex music, and promote expressivity and virtuosity. But perhaps their category of ‘infra-instruments’ is most helpful in understanding Hand2Hand and Dot2Dot. Infra-instruments, in contrast to the above, provide the user with a constrained range of interactive gestures and repertoire. They also engender relatively simple music and are restricted in terms of their virtuosity and expressivity.

More widely, infra-instruments may be a useful concept that could help educators maintain a focus on the educational purpose and functions of a particular technological tool for a specific purpose. They encourage a deliberately restrictive approach to instrument design and use. For the educator, this is akin to tailoring a particular task or activity to

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achieve a specific learning objective. The tailoring or restricting might not last for long, but it will be long enough to achieve the educational aim. Consider it from the other way around. What use is it giving pupils large, complex instruments that have multiple functions and immense learning curves, despite being wonderfully expressive in the hands of a virtuosic user? For some, this will be the answer (and there are many stories from the lives of professional musicians where this has been the case). But for others, perhaps the majority, their engagement with music has been compromised or hijacked by insensitive, inflexible and untimely pedagogies that have prioritized traditional approaches to instrumental learning at the expense of everything else. Within this scenario, perhaps simple software and hardware instruments that use ‘everyday’ technologies to encourage musical processes such as performing, reading notation and the like have a role to play?

Despite the apparent technological reversals of instrument design that infra-instruments demonstrate, Bowers and Archer argue that infra-instruments are nonetheless ‘aesthetically engaging and technically intriguing’ (Bowers and Archer 2005: 6) and worthy of further study. Our work developing Hand2Hand and Dot2Dot shows that they have educational potential too.

5. Performance ecologies

Handling an assembly of stuff is often facilitated by an infra-instrument design philosophy, where each device plays its part in a manageable hybrid environment. [...] The whole performance setting becomes the unit of analysis, design and evaluation, not just a single ‘new interface for musical expression’.

(Bowers and Archer 2005: 6)

Finally, the analysis turns to what Bowers has, elsewhere, called the ‘performance ecology’ of music (Bowers 2003). For Bowers, performance ecology is the place of practical action (i.e. music-making), and he is particularly interested in how this is displayed to others (e.g. other performers or an audience). Bower’s examples include desktop performance ecologies that may:

• Be differentiated (a place for the computational, for the acoustical and for other tools)
• Be integrated in various ways
• Allow opportunities for juxtapositions and for legible embodied conduct (how performers look for, reach for, touch, communicate in non-verbal ways, etc.)

Performance ecology has a rich resonance for those involved in formal, classroom-based music education. It takes our consideration away from aspects of software design and development to the wider context of the classroom. It challenges us to situate the design and development of specific educational software instruments within this context, and to consider how their use promotes musical learning and development.

There are many potential directions in which this could lead. One particular avenue has been at the forefront of our thinking since completing
these case studies. It concerns the adoption or appropriation of visual
domains for music education.

Steiner (2005) examines the production of a unified framework for
Human Interface Devices (HID) instrument design. His experiments in
compiling a HID toolkit provided thirteen objects that allowed users to
build a range of computer music instruments. Through this process, he
observed that:

Modern computer graphics capabilities enable vast possibilities, but visual
feedback for musical instruments and even visual (virtual?) instruments
remains largely under-explored. Computer based instruments could pro-
vide richer visual feedback than any traditional instrument, but this idea is
largely unexplored.

(Steiner 2005: 143)

Although there have been a number of rich visual environments to help
facilitate musical composition (e.g. Metasynth), the development of these
concepts within musical performance seem under-exploited, particularly
within the field of formal music education. As the speed of real-time syn-
thesis and analysis has increased, games such as SingStar (Sony 2009)
and Guitar Hero (Activision 2009) are beginning to offer performance
feedback through the visual medium. But these remain within the con-
finies of the computer screen. Given that the visual domain is central to so
many cultural activities and experiences in the early twenty-first century,
it would be apposite to consider how visual environments would impact
this wider performance ecology of musical learning. This is one of the
future directions for this research.

**Conclusion**

The educational potential of digital technologies for the teaching and
learning of musical performance is an emerging field. It seems likely to be
at the forefront of music educational developments in the coming years.
These case studies explore a number of important issues, but there will be
many more that emerge as research continues. Perhaps the most impor-
tant questions that need to be asked relate to the nature and purpose of
music performance as an activity in itself. Why should musical perform-
ance be live? What difference does it make? These are questions that have
been addressed in recent years (Reimer 1994; Savage 2007) but remain
vital for future curriculum developments. For Buxton (2005) musical
performance is a compromise between the presentation of the scored and
the improvised where physical, emotional, gestural, active and reactive
components all have a part to play. Within this, Buxton comments on the
visibility or invisibility of gestures for the ‘act’ of musical performance:

I must confess, that I have the same emotional and intellectual response to
watching someone huddle over a laptop as I did 20–30 years ago when they
were huddled over a Revox tape recorder. The more invisible the gesture and
the more tenuous my perception of the correlation between cause and effect,
the less relevant it is to me that a performance is ‘live’.

(Buxton 2005: 4)
Current observations of pupils working in classrooms (Fautley and Savage 2008; Savage 2009) reveal a technological preoccupation with compositional tools such as Cubase and Sibelius. These compositional tools dominate much music teaching at Key Stages 3 and 4. This does not bode well for the future of musical performance within the classroom. There is a real danger of pupils becoming isolated from each other in their music-making as they get drawn into the screen and, in Buxton’s phrase, their musical gestures become more ‘invisible’ to all but themselves. Designing, developing and prioritizing a performance practice for digital musical performance tools and situating this within an educationally rich performance ecology seem like essential tasks for future research and development. But as with any educational development, it will not be necessary to start from scratch. As this article has shown, there are interesting and provocative takes on many of these issues from a wider community of performance artists, electroacoustic musicians and computer programmers. Educators need to maintain a broad vision and a sharp eye (and ear), to keep abreast of technological developments and be imaginative in their application to the broadening context of teaching and learning. It is hoped that these case studies have given an example of at least some of these aspirational goals.

References

Suggested citation

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