Providing access to music making for people with physical disabilities and visual impairments

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Abstract

This paper discusses ways of giving visually impaired and physically disabled people access to composing and performing music. The usage and adaptation of existing software-based composition systems is described, in the context of education work undertaken by the Drake Music Project - a charity which aims to facilitate disabled people in making music via technology. Some of the problems faced are discussed, and a custom system presented which aims to resolve some of these difficulties.

Introduction

Disabled people who want to compose or perform music may need to be assisted in various ways by a computer-based system. Appropriate computer software can help a disabled person to enter and organise musical material which may then be played. In addition, some systems may enable even a severely disabled person to perform live by triggering a pre-selected sequence of prepared music.

Disabled people may also have little experience of playing a musical instrument, which may mean that they lack the 'feel' for musical shapes which is typically built up over time. People may thus need more guidance than normal to make up for this inexperience, as well as guidance in using the often complex music software.

Background - The use of existing systems by the Drake Music Project

The Drake Music Project is a charity which aims to provide physically disabled people with access to music making and music education through the use of music technology (Smith 94). Its activities also encompass research, development and assessment of systems to facilitate disabled access to music making.

During Drake workshops the tutors not only teach music through group and individual sessions, but spend time determining the appropriate equipment and interfacing for each person to use most effectively.

The emphasis is on utilising easily available 'off the shelf' products wherever possible. MIDI controllers are in regular use during workshops: these include keyboards (with standard or miniature size keys), percussion pads, spatial position detectors[1], and movement to MIDI converters[2] utilising various sensors and transducers.

As well as triggering individual sounds (from synthesisers or samplers), a MIDI controller can be used (with appropriate software[3]) to initiate, select or step through pre-prepared chords or sequences of notes. The MidiGrid software also allows computer mice, trackerballs, and joysticks

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1 Eg. Ultrasonic beams such as 'MIDIGesture' (MIDIcreator) and 'Sound Beam' (www.soundbeam.co.uk).

2 Eg. 'MIDICreator' (www.midicreator.com / www.immersivemediaspaces.co.uk).

3 Eg. 'MidiGrid' (www.midigrid.com) or 'Max' (www.cycling74.com).

to be used as performance controllers (or any switch via an adapter). Drake is also developing software to facilitate group performance in a flexible way (Anderson 94).

Group and individual performance work is supported well by such systems, but another important emphasis for Drake is on facilitating composition by individuals. The interest in creating and playing back music can potentially provide a high degree of motivation for perseverance in learning to use a composition / sequencing software system.

However, currently available standard systems are usually not an effective solution for severely physically disabled people. A number of often interrelated factors can reduce motivation and interest in using systems independently. Factors can include: (a) the complexity of use of the system or its visual presentation; (b) a lack of reading skills; (c) insufficient size and clarity of the screen; (d) lack of continuous one-to-one teacher guidance due to the size of a group; (e) difficulties in operating the system without full mouse/track ball control.

Thus, in many cases, a severely disabled (eg. single switch-using) musician is able to learn the skills necessary to compose music, but *not* how to use a composition system except through example - a tutor has to operate the software in response to the musician's decisions.

One of the aims of Drake is to provide musicians who want to work independently at a professional standard with the necessary skills to do so. The quality of the music presently being produced by some of Drake's clients warrants the aim of facilitating complete independent control of the composition environment by people with any degree of disability.

Two approaches have been taken by Drake to improve disabled access to composition systems: (i) adapting, extending or combining existing software and hardware, and (ii) creating bespoke solutions. Both approaches have their good and bad aspects, and are examined in the following two sections.

Adaptations of standard systems for improved disabled access

Some of the kinds of adaptation designed to aid physically disabled and visually impaired users are here briefly discussed, in the context of hardware and software currently used for musical purposes.

(i) Adaptations oriented towards users with physical disabilities

Most, if not all, of today's professional standard music software is now WIMP-based. Many systems also provide a number of 'keyboard shortcuts', and some even allow various functions to be controlled via external MIDI commands. However, many functions (typically operations within dialog boxes, or selecting blocks of notes) still require some use of the mouse.

A variety of hardware and overlay software is available to assist in the control of such systems by mouse and keyboard:

• Switch-controlled menu-driven overlays to emulate mouse or key press actions. These attempt to allow a user to emulate mouse pointer movement, mouse button presses (eg. click, hold, double click) or console key presses by using one or more switches and a menu system. An example for the Macintosh is 'Ke:nx'.

• External switches replacing mouse buttons. Many users have difficulty in pressing or holding a button on mouse or trackball while moving it, or keeping the cursor in the desired screen location. Other users have difficulty in 'dragging' with the mouse, ie. moving it while holding down a mouse button position at the same time. External switches can replace the 'on board' mouse buttons, and may be able to be locked down. This can be very effective for such users: for example, the simple facility to be able to lock down the mouse button may enable someone to fully utilise a trackball using their foot.

• Keyboard aids. Other common aids allow the user to hold down console keys, allowing combinations of keys to be 'pressed' with only a single finger or, for example, a head pointer. Other aids can prevent a held key from repeating (so multiple presses will be ignored). Examples are the 'Slow keys' and 'Sticky keys' features of the Macintosh 'Easy Access' system software.

• Macros. Various utilities allow a user to record 'macros' - each is a sequence of actions which can then be initiated with a *single* action. Such facilities are often used in conjunction with other adaptations.

• Switch emulation of mouse operation. External hardware can allows a joystick or switches to emulate mouse movements (eg. the 'MouseStick'). Key presses on the console can also emulate moving the mouse pointer in different directions or holding the buttons down. An example is the 'Mouse keys' feature of the Macintosh 'Easy Access' software.

Such adaptations can be very useful but, when used with WIMP-based music systems, are not an ideal solution for a variety of reasons.

Many systems - and particularly music software - present the user with a vast choice of actions. There is a large 2-dimensional control space within which to move the mouse pointer (even if using the above aids), with many icons and displays which present a small target area. When over an icon, the user may then have to press one or more mouse buttons, and hold or drag. This may have the effect of scrolling through many values or options, or present a pop-up menu or a dialog box containing further fields, sliders and buttons. Thus, a single operation can involve numerous disparate user actions.

There is often no indication of how to approach a task. While a beginner is learning to use a system, there is often a lack of feedback, encouragement, and quick 'default' results - everything has to be done correctly before the desired outcome is achieved (eg. some music is heard).

(ii) Adaptations oriented towards users with visual impairments

Many hardware and software add-ons are available to help people with partial or total visual impairments to use standard software. Some typical examples are briefly presented:

• Screen readers.

Such systems typically consist of overlay software linked to a speech synthesiser. They usually speak words as the user navigates a cursor around text displayed on the screen, and are therefore less useful with more graphically-based software. An example is the 'HAL + Apollo II' system which works effectively with DOS-based music sequencer software such as Voyetra systems 'Sequencer Plus' or Twelve Tone Systems 'Cakewalk'. A set -up 'environment' file for the latter is included with HAL as standard; this also makes it easier to write environment files for other DOS-based sequencers. Research at University College, Bretton Hall has shown that the 'Cakewalk' and Voyetra sequencers are the most widely used by visually impaired people.

There are also many language-based composition systems which could be successfully used with such screen readers, but they necessarily possess a degree of complexity which makes them less approachable by the majority.

Some screen reading systems can work effectively with text within a WIMP environment, and can read text or numbers on the graphical screen display - an example is 'outSPOKEN' for the Macintosh. However, outSPOKEN does not recognise standard music notation or graphical icons, so is not a complete solution for most music composition systems. Another example is 'Metaphor' (Aldridge Technologies) for the Atari computer - a platform still widely used for music software in Europe. Metaphor can also translate a graphical environment into spoken text, and has been successfully used with the Cubase sequencing system by a number of users in the UK. The attraction of Metaphor for most visually impaired people is not only the power of the music application and screen reader themselves, but the opportunity to be using a mainstream system which is in widespread use.

Continuing research and development in this area means that the range and quality of this kind of adaptation is likely to improve in time.

• Screen magnifiers

These software overlays enlarge the bit-mapped display, enabling people with some types of partial visual impairment to effectively use any software. The user only sees part of the original screen at any one time, and can navigate the enlarged view around the screen.

Examples are 'LUNAR' for Windows, and 'CloseView' and 'inLARGE' on the Macintosh. These systems work effectively with music software packages, although problems can arise: at high degrees of magnification, the proportional screen area on view can be so small that the user can have difficulty in navigating around the screen. In addition as the software simply replaces each pixel by a block of the same colour pixels, the enlarged display can become extremely jagged and difficult to interpret.

Screen readers and screen magnification systems for Windows, such as 'Windows Bridge' and 'JAWS' have been used with some degree of success with music applications. However, one example of a difficulty experienced when using these systems is with 'Cakewalk Professional' (for Windows), which is presented visually as a grid of 'cells' (with tracks laid out vertically and their parameters horizontally). Movement around the program is via a highlighted box that surrounds the current 'cell', but to date, no Windows overlay will recognise these cells.

A custom software composition system for disabled users

Having examined a few of the adaptations which attempt to provide some degree of disabled access to standard software, we now look at a bespoke solution. Drake has been developing a software system for music composition and education called 'E-Scape', whose operation and user interface have been designed from the outset to facilitate unaided use by people with a wide range of disabilities and experience. 'E-Scape' incorporates a number of features which can help to surmount some of the problems with the adaptations discussed above (Anderson 93a).

E-Scape can operate under single or multiple switch control, and allows the user to choose musical elements such as timbre, note position, pitch and duration for different tracks of music. Material can also be copied and moved, or loaded in from a library. A user can thus build up and finely edit a multi-tracked musical piece.

Every operation in E-Scape - without exception - can be effected by selecting options from menus. These menus can be controlled by mouse as normal, but also by the computer console, or by one, two or more switches. In addition, menus can be controlled by MIDI equipment; thus, for example, a MIDI drum machine, movement sensor or keyboard can be used to operate the system if desired.

The system is, however, completely window-based with graphical score displays; a mouse user can operate it completely normally as a WIMP environment. At the other extreme, a single switch user is able to exert the same control, albeit more laboriously. If the user presses a switch (eg. a console key, an external switch, or some MIDI gadget), a top level menu will pop up. If in 'single switch' mode, this menu then scrolls down its options by itself, and the same switch can be pressed to select the desired option. In 'multiple switch' mode, each further switch press scrolls down one item; a second switch can then select the desired item. If the user can use more switches, these can enable faster and more flexible operation, eg. a third switch can scroll the menu up; a fourth can scroll it down *several* items at once (useful for long menus of filenames, for example).

We will now consider two aspects of the user interface provided by E-Scape, and their effect on its usability by disabled people.

(i) Control - provision of flexible physical interfacing for system control by user

A user can employ any available interface to control the system, allowing him/her to interact physically with the system in a variety of ways, using a wide range of movement types and extents. Control can be totally effected by a single switch, or use several switches, a mouse, a joystick, the computer keyboard, or any MIDI messages, or any combination of these.

Movement can be detected via an appropriate sensor and analysed, so for example, a change of motion by the user can act as a switch.

The way the interface is used is customisable by the user. For example, a notional 'switch press' could be effected by any or all of the following actions:

- hitting an area of the computer keyboard;

• hitting a zone of notes on a MIDI keyboard, or one or more drumpads;
• a reversal of movement (using a distance to MIDI converter);
• jumping on a floor pad (connected via Midi Creator);
• moving a MIDI keyboard's pitch bend lever to the left;
• pressing a mouse button;
• making a sound (using a sound to MIDI converter).

Users can thus tailor the interface themselves to their own particular needs, which may alter as their physical capabilities change.

(ii) Economy of effort - reduction in the number of actions required to carry out an operation

Physically disabled composers often have a restricted communication bandwidth - each control action can take a long time and consume much effort, and it is easy to accidentally select an undesired option. E-Scape provides for many operations to be carried out using only a few actions - minimally with only a single switch press. Disabled composers are thus able to undertake repetitious processes more quickly and easily - requiring less work *apart* from the crucial *compositional* decisions.

There are different 'user levels' which have different ranges of options and terminologies. Two examples can illustrate this:

(a) At 'user level 2' the *'Play'* option will simply play the entire visible score page. At 'level 3' the user would instead be presented with a further menu of options (*'Play this track'*, *'Play from start'* etc).

(b) At level 2 the *'Make note higher'* option (described below) simply transposes notes repeatedly up by one semitone. But, at level 3 this option is instead presented as *'Transpose up'*, and again has a further menu of options (*'Up 1'*, *'Repeat up 1'*, *'Octave', 'Other...' etc*).

Thus, if users' skills and compositional experience improve with practise, they can choose to progress to a higher level; requiring more decisions, but with a resulting increase in flexibility.

The provision of an immediate musical result, with instant automatic audio feedback at each stage, is also very motivating in the early stages of the learning process. Many severely disabled people want to make a lot of sound and noise using a real-time controller if they possibly can, as often this is the first time they have had the opportunity to do so. The fact that users can produce some musical results before they have started to learn to compose fulfils that need for immediate feedback. Lack of results, when a lot of effort is required, is one of the reasons why many people become disenchanted with using existing software.

Current E-Scape features which support visually impaired users

At the existing stage of development, E-Scape has several features which facilitate use by visually impaired users, through its flexible operation, and presentation of information to the user:

(i) Operation and orientation

• All interaction with the system may be via non-mouse input.

Options can either be selected by a keypress, or via a switch controlled series of menus. The text-based nature of most of the E-Scape control system (although the score display is graphical) means that speech output can be a valid option.

• Menu items can have sonic or vocal feedback.

It is possible to use the in-built facility within E-Scape to assign speech samples to menu items but - for a user who is more familiar with it - the use of 'outSPOKEN' does not interfere with the keyboard control of E-Scape (as outSPOKEN is operated using the numeric keypad).

• Automatic auditioning of sounds.

One of the advantages of E-Scape for the visually impaired user for whom screen magnification is not a viable option is the fact that it is not really necessary to see the screen at all if speech output is present. The score display is not of essence to the musical result, as it can be played, and notes or groups of notes auditioned at any time. For example, when selecting sounds from a menu, each item plays itself automatically.

(ii) Score and menu display

Various choices offered to the user regarding the visual presentation of score displays and menus enable the system to be finely tuned for a partially sighted user. For example:

• Scores are displayed as graphic bars ('piano roll' style) on a horizontal time-line; the colour and height of the bars are alterable by the user.

• The colour and width of the play and step entry cursors (vertical lines on the score display) can be altered (up to several cm wide if desired).

• The colour of pop up menus can be altered by the user: different colours for text and background can be selected for the menu title and each of its items.

• The text size for menus and alert boxes can be selected by the user; at the highest practicable size (about 80 point text) a single menu item fills the entire screen, but the text is still smoothly drawn. If this is still not large enough, the user can switch on a screen magnifier and further magnify the text.

(iii) MIDI considerations

E-Scape is designed to obviate the need for a user to operate or look at the sound devices in use; once a device has been set up, it can be left alone. E-Scape is aware of the state of connected device at all times (as long as it is not disconnected or fiddled with!), and can control each device as necessary. The user is completely shielded from the MIDI protocol and device terminology: for example, the user does *not* need to know about such things as MIDI channels, patch numbers, bank changes, program change maps, pitch bend sensitivity, controller numbers, system exclusive strings etc.

This helps to alleviate another problem facing visually impaired users, namely the common usage of LCD panels on MIDI keyboards and modules. Many LCD panels are quite small, and in the main the colour contrast is not high enough to make it a viable way of accessing information for the partially sighted, and not at all for people with total visual impairment. There are some exceptions: for example, some devices employ fluorescent displays which can be used by some partially sighted people.

A comparison of using custom and mainstream composition systems

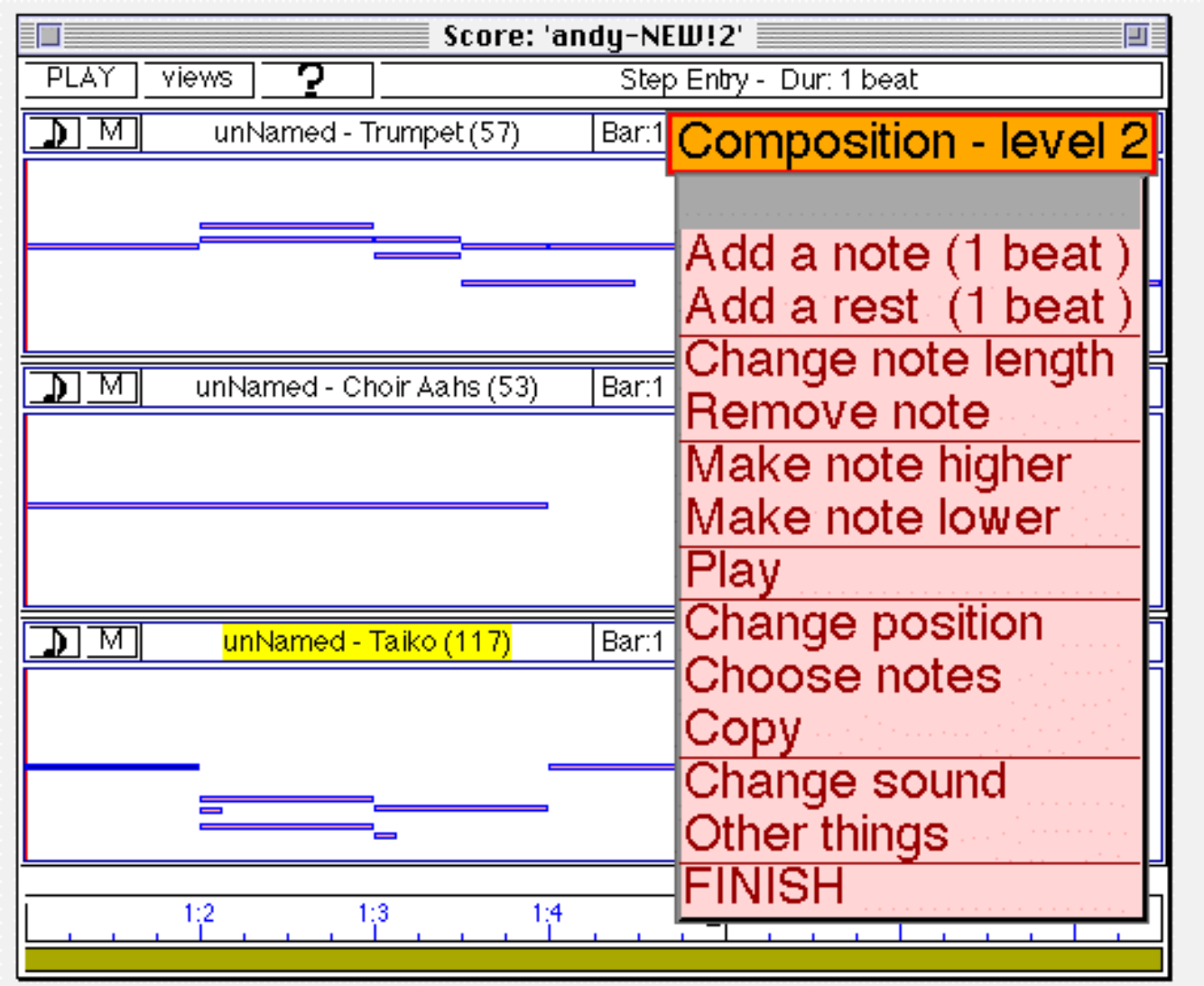
'Cubase' is an industry standard sequencing package used by Drake, and is powerful enough for most mainstream musical applications. Cubase may be used together with many of the adaptations discussed above, which can in some cases allow a disabled person to operate it. However, the operation of the system is *not* viable for the majority of severely disabled people - many problems remain.

Adaptations which enable a switch user to emulate mouse and keyboard operation can at least make usage physically possible, but operating Cubase requires a large number of precise mouse movements and holding and dragging operations (not all Cubase functions have keyboard shortcuts, by any means). Usage in these circumstances can be highly laborious and prone to errors or confusion, eg. forgetting when one has left a mouse button locked down can lead to difficulties.

Overlay software with macros incorporating mouse operations can help to perform certain operations, but screen locations recorded in the macro are not context sensitive in most cases; eg. which window is open, where it is, or the current state of the edit screen (zoom amount, time location etc.). Such systems thus provide only a partial solution.

By contrast, E-Scape is designed to require far fewer operations to achieve a particular task.

Firstly, *every* operation can be carried out by selecting it from a menu using a *task-based* name (eg 'Choose notes', 'Change note length'). An example is shown below.



The 'Level 2' main menu in E-Scape

In addition, related actions involved in performing a particular task are carried out with a degree of automation - by anticipating the kinds of operation a composer is likely to want to carry out. Three examples will illustrate this:

(a) The 'Add a note' option inserts a new note, then the music surrounding the new note starts playing automatically; this repeats until the user presses a switch.

(b) The 'Make note higher' option repeatedly transposes the selected note(s) up one semitone at a time, then auditions the result by playing the surrounding music. The user (who may not initially have the musical experience to know how much to transpose the note up) can simply *listen* to each audition, and press the switch when they hear what they want. Knowledge of intervals etc can come gradually, but is not a pre-requisite for immediate achievement, and the resulting motivation to go on.

(c) The 'Copy' option first gets the user to select the notes to be copied (via further menus), then straight away prompts him/her to go to where the notes are to be copied. The notes are then pasted there with no further user involvement needed. Compare this with the same operation in Cubase and other sequencers: the user must remember to first select the notes to be

copied, and only *then* select the 'copy' option - after which *nothing happens*. The user must *then* go to the place where the notes are to be pasted, and then select the 'paste' option. Experience of teaching people to use Cubase has indicated that this is *not* intuitive!

Such features of E-Scape are designed to help users focus on *musical* rather than operational issues, and evaluation so far with novice users bears this out.

Continuing development and assessment of E-Scape

E-Scape is undergoing continuing development, which will allow it to be tailored effectively to real-world needs, and expand in its range of usefulness. Several aspects of this development can be considered:

(i) User evaluation

Informal evaluation of the E-Scape system in use by students in Drake workshops has been undertaken since mid-1995. Observations so far indicate that E-Scape is successful in allowing people even with severe physical and/or cognitive difficulties to approach the task of unaided music making, for the first time in many cases. User reaction has generally been extremely enthusiastic. The fact that non-readers who have had no previous experience of composition have also been able to use the system has been very encouraging.

This feedback is resulting in continuing refinement, redesign and expansion of the E-Scape user interface.

(ii) Planned additional features

Features already planned for the next update of E-Scape include:

- each system action providing context dependent information (eg. the basic action 'select next note' could not only announce this via a speech synthesiser, but also play the note, and/or announce various parameter values of the note);

- further customisation of the visual presentation, eg. altering window background colours, border sizes and colours etc.;

- menu items able to be user selectable icons;

- the provision of a moving 'zoomed in view'. This could be better than the screen enlarger adaptations above, as the image would not be jagged, and the area which is enlarged would be context sensitive, ie. be the area of current user focus.

Such features will be evaluated with visually impaired users, and feedback and ideas provided for the further enhancements and features required to facilitate *complete* control and use of the system by people with any degree of visual impairment

- import and export of MIDI files, enabling transfer of music to and from other systems. Users who wish to enter professional music working environments will naturally want to use the current 'industry standard' system if at all possible, so it is important for previous work to be transferable. Indeed, one of the aims of the Drake is to provide training pathways to enable people to progress into the mainstream world of music.

(iii) Additional areas of utility for the system

When fully developed, E-Scape may be useful in a wider variety of settings than originally envisaged.

• In special or general education, students will be able work through a set of prepared didactic 'Activities', within which they can be allowed an appropriate degree of creative freedom, making musical decisions and choices. Students can start with 'beginners' activities where there is little user choice required. Activities with no choice at any stage could even allow a student to merely step through the process, observing the effect of each action. As students gain more experience and confidence, they can gradually progress to successive Activities which allow them to exercise more control - having to make more compositional decisions, and having more freedom to navigate between actions within the Activity.

Music educators will be able to construct sets of Activities which guide a student through a chosen compositional process. Students can thus be guided through a compositional process, progressing to activities which demand more decisions, enabling them to learn by participating in an active process. Suitably designed activities could even allow a student to compose within the framework of a particular compositional methodology, while allowing partial or full decision making. Further developments could enable students to customise their own working environment as they progress - altering existing Activities or constructing new ones.

• Music experience and enjoyment for people with learning difficulties could be provided; people can enjoy creating music, within a 'safe' environment, with an appropriately restricted set of options and choices to make. Activities can be designed which allow a user to make musical decisions at a high level, with activities able to proceed with little further user interaction. For example, a user could select a melody from a library, choose the kind of accompaniment style or change the tempo and key etc. All decisions produce some kind of musical output, and hence maintain motivation and interest. Users can progress to more interactive activities as their skill and confidence grow.

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