DrumSteps - A Constructionist Approach to Music Learning

Introduction

Over the past number of years, increasing emphasis has been placed on the application of computers and technology in education. This emphasis has not always been accompanied by rigorous examination of exactly what the role of all this technology should be. A variety of approaches have been suggested and tried in different subject domains and settings, with varying degrees of success. These have included internet and web based learning exercises, multi-media based approaches and the deployment and use of commercial software. At this point there is still surprisingly little evidence to indicate whether these types of approaches are more or less successful then traditional teaching and learning methodologies. This paper will briefly outline some of the approaches typically taken in the application of technology to music education, discuss some of the associated difficulties and suggest an approach to music education software design that, it is hoped, goes at least some of the way to dealing with some of these difficulties.

Categories of Educational Software

Approaches to computer assisted learning are typically described as falling into four main categories; Drill and Practice, Tutorial, Game and Simulation[i].

Drill-and-practice software is usually designed to give the student repeated practice on lower level cognitive skills, e.g. note-reading programs, aural training software. The underlying learning model is behaviorist (stimulus, response, and reinforcement), i.e. the computer selects and presents a problem, the student responds, the computer evaluates the student's response and provides positive or negative feedback based on the student's response. The procedure is then repeated until the set of tasks is completed.

Tutorial software usually assumes no previous knowledge of the content being taught and attempts to present the material in a logical sequence which fosters understanding. It will often includes such elements as animations, musical examples (audio and MIDI), video and graphic elements and may have a degree of evaluation or drill and practice built in, along with the capacity for forward and backward movement, and the ability to search for specific text.

Game software introduces some element of scoring or competition into the learning process. Students must indicate their understanding of some educational content but in competition with either the computer or another student. Points or scores are awarded and frequently a time limit is used to encourage the student to respond quickly. Game software, like drill-and-practice software, usually assumes some previous knowledge of the content being taught

Simulation software attempts to set up an environment in which the student may manipulate the various elements on the computer screen, thereby discovering aspects of the real world domain from which these elements are drawn. Educational content is usually implicit rather then overtly stated.

Problems with Educational Software

While educational software can offer considerable benefits, there are many factors quite apart from obvious design criteria (usability, layout, ease of navigation etc), which can reduce its effectiveness.
These include:

- Interaction with the interface, not the content.

Many software applications and multi-media presentations, while well designed offer no guarantee that the user is interacting with the subject matter in a meaningful way as opposed to merely 'surfing' the interface

- Testing vs Teaching

Much music education software has a large drill and practice component as outlined above. The underlying assumption here is that the learning has happened elsewhere and the only function of the software is to in some way reinforce this learning.

- Information vs Knowledge

Even if the software is designed so as to maximise interaction with the material, there is often no way to be sure (in the absence of a supervising teacher) that the learner is in fact converting the information presented into personally meaningful knowledge. Even those elements of feedback which are typically built into educational applications rarely go beyond the right/wrong paradigm, and in most cases, the software will allow the user to progress to the next 'level' without any clear indication that the current material has been assimilated.

- Emphasis on lower cognitive processes

Blooms Taxonomy of Educational Objectives (Knowledge, Comprehension, Application, Analysis, Synthesis, Evaluation) offers a hierarchy of abstraction of questions that commonly occur in educational settings. One of the biggest difficulties inherent in a computer-based approach is how to enable the learner to access the higher cognitive processes. Even in well designed multi-media presentations, it is rare to find exercises which progress much beyond the comprehension stage.

Constructionism

An alternative approach to the deployment of computers in an educational setting arises out of the work of Seymour Papert.[ii] In it he postulates that one of the reasons children have difficulty in mastering the concepts of a given domain is that very often these concept are based on principles which fall outside the range of their normal 'real-world' experience. He suggests an approach based on the idea of a 'microworld'.

A microworld is an immersive environment (real or virtual) which allows the child to interact with the elements of a given domain and carry out operations appropriate to that domain, thereby gaining intuitive knowledge as to the 'rules' which govern it. The microworld serves as an intermediate, a bridge between the child and the domain, facilitating the construction of learning paths from the childs real world experience and knowledge into that needed for understanding in the abstract world of the domain. The principal attributes of a microworld are;

- There should be continuity with some well established personal knowledge
- The environment should empower the user to perform some personally meaningful projects/operations
- There should be some element of construction and experimentation
- It should engender procedural thinking (iteration, debugging etc)
- It should be equally useful/appropriate for both novice and expert
- It should make sense in the larger cultural context

In Paperts vision, the most appropriate use of computers has nothing to do with the transmission of information. Rather he sees computers as a tool to enable children to do things that they couldn't otherwise do. They build, make or manipulate objects or artifacts and in so doing are confronted with the results of their actions, learning as they go. The physical or virtual 'building' acts as an external manifestation of the internal process of constructing knowledge which must take place in the course of completing the task. The underlying philosophy is referred to as ‘constructionism’, the external manifestation of constructivism.

The ‘Design Space’

A similar approach underlies the work of Rafael Granados[iii] in the domain of mathematics education. Much traditional learning takes place in what he calls a ‘problem space’. This is a conceptual space which consists of a well defined problem statement for which there is a clearly defined set of actions leading to a correct answer.

The idea of a ‘design space’ stems from problems of a different nature. In a design problem, there is no clearly defined problem statement, action set or answer. Rather, learners are required to build their own criteria for deciding on the most useful approach to an open ended problem for which there is no clearly defined solution. Solutions are only better or worse in various ways when compared to one and other. Learners will go through cycles where they continuously refine their understanding in order to arrive at progressively more satisfying solutions.

This concept may easily be applied to activities in the creative arts, particularly in the area of music composition, where the right/wrong paradigm may not be appropriate.

Technology in Music Education.

Kieth Swanwick[iv] makes a clear distinction between core musical activities, which he defines as composing, listening and performing, and secondary or supporting activities such as skill acquisition and literature studies. The key point here is that while the secondary activities are worthwhile, the focus needs to be very much on the core elements. The question for teachers and technologists alike is, “to what extent and in what areas can technology facilitate children to participate in these core musical activities in ways that could not easily be done by traditional means?”

While standard multi-media presentations can be useful in the area of literature studies and possibly in designing structured listening activities (although building in a feedback element to ensure that the listener is actively engaged can present problems here), they are of little value in the performing and composing modalities. Enterprising teachers can and do create valuable and meaningful experiences for their students using proprietary notation and sequencing software (Sibelius, Finale, CuBase etc). However, these packages are designed primarily for the professional practitioner and do not have an inherent educational aspect. They also have a very steep learning curve which makes them unsuitable for all but the most gifted music student without considerable help from the teacher. There is a clear need therefore, for technology based resources built on sound pedagogic and design principles which will enable the learner to access the core musical modalities in an intuitive way.

In the performing area, solutions typically consist of attempts to build easy-to-use, non-standard physical interfaces, instruments or musical toys which, when combined with computers and synthesizers can enable children to participate in musical performances without the long learning curve associated with traditional instruments.[v]

For composing activities, a screen based approach may be effective without the need for expensive extra hardware. Computer interfaces can be designed which allow children to make and manipulate musical elements without the need for either prior training, instrumental skills or the ability to read standard music notation. The issue of notation is an important one. While it is relatively easy for children to generate short musical ideas using whatever materials or instruments are to hand, it is a much more difficult problem to manipulate these on a larger scale so as to confront compositional ideas such as texture, form or structure.

In order to facilitate this type of activity by traditional means it is usually necessary to learn note reading skills first. This is a very difficult hurdle for the young musician to overcome. Very often, standard notation can act as a barrier rather then an enabling tool, drawing the learners focus onto itself rather then directing it towards the music it represents. Many younger music students intuitively perceive music in aggregated units (phrases etc) rather then at the formal 'note' level making a notation based approach particularly difficult for them.[vi] A well designed computer graphical interface should be able to bypass the notation issue thereby enabling the kind of musical manipulations that might otherwise not be possible.

The rest of this paper describes a computer based constructionist approach to the area of rhythm and percussion composition, which attempts to provide an intuitive graphical interface to enable children to make and manipulate musical ideas and hear the results of their work.

DrumSteps – A Percussion Composition MicroEnvironment

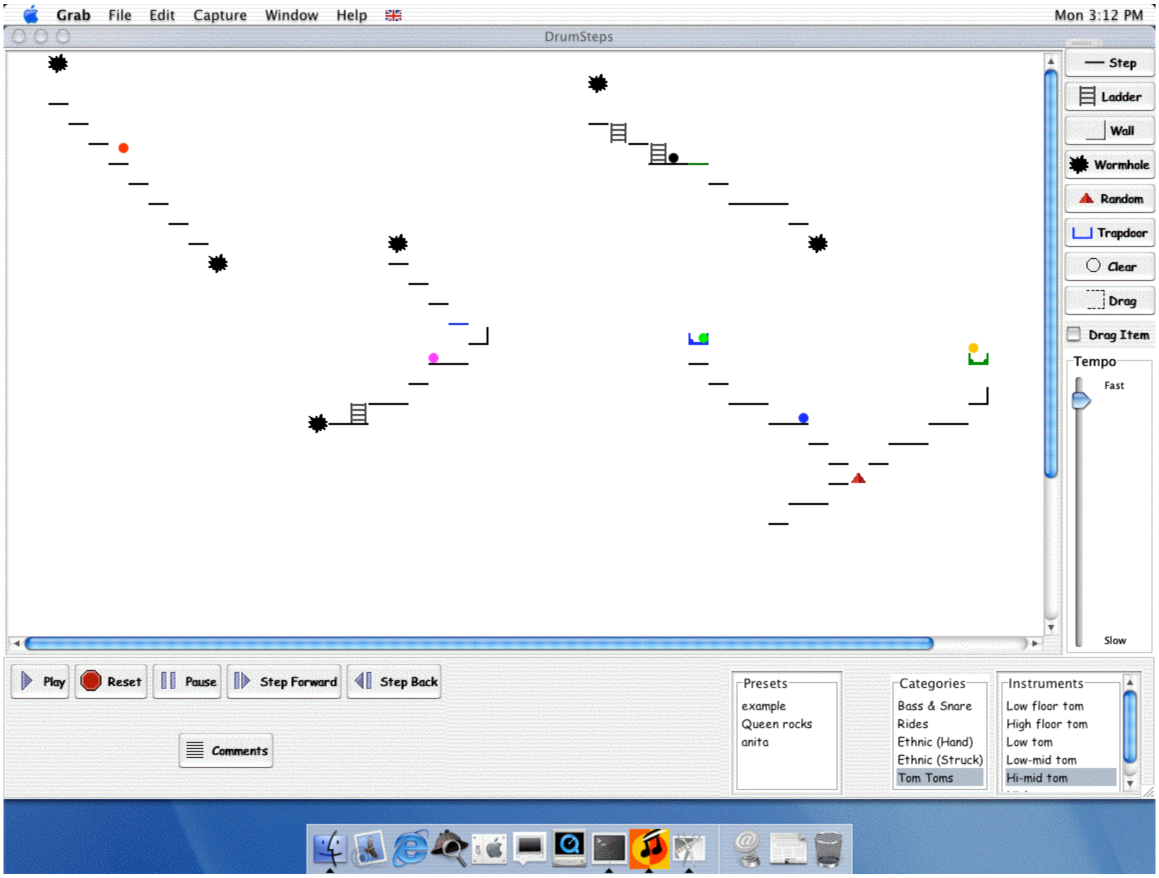
This is a screen-based virtual environment which allows the user to build sets of steps and produce percussion sounds by dropping balls down the steps. The number of horizontal steps controls the time between notes while the height of each step controls accent/volume. Timbre is embodied in the ball and the full range of general MIDI percussion sounds are supported. Multiple ball/step combinations allow for multi-part 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 etc.

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 'randomizer' icon giving each ball multiple possible paths, a 'ladder" icon for subdivided note groups etc. 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 It is possible to capture step sets and store for later use. A journal feature allows the user to make comments detailing their thoughts throughout the composition process which is saved with the composition.

The following are some of the important characteristics of the system. It is;

- Constructivist – Music is 'embodied' in the structure
- Flexible – suitable for all levels of proficiency
- Iterative/editable- encourages procedural thinking
- Consistent – actions/operations produce clearly definable results
- Based on intuitive world knowledge (objects falling etc)
- Notation free – Standard music notation is not required, although the step structures themselves act as a kind of 'embodied' notation.

Figure 1. DrumSteps



Controls (as shown, right of screen, top to bottom); place steps, place ladders, place wall, wormhole, randomizer, trapdoor, clear, drag, tempo. Standard playback controls shown bottom left.

Exercises using DrumSteps

Pedagogic exercises using this type of system would be task oriented. They might fall into a number of distinct categories

- Listen and create
  Exercises of the type – 'How would you make this sound…..?'

  Having become familiar with the system by playful exploration, the learner would be confronted with a graded series of exercises requiring them to recreate given rhythms. These would be presented aurally by the system and would be initially in one voice/part and move through the rhythmic hierarchy from crochets through quavers, semiquavers syncopations, dotted notes etc., gradually increasing in length, complexity and number of voices. When the student has gained ability to recreate given rhythms, the next stage might be to create their own rhythms based on simple instructions. For example, a moderately easy exercise might be to make a two-part texture with one voice on the beat and the other offbeat. Eventually students would be encouraged to create original self-directed percussion pieces which might then be performed instrumentally.

- Listen and perceive
  Exercises of the type – 'which ball is doing this…..?'

  The student would be presented with a prepared multi-part texture. The system might give a rhythmic idea or motif and the students would be asked to find the ball which was making that particular rhythmic pattern, encouraging active listening and developing motivic awareness and the ability to listen in to a multi-part texture and abstract particular information. Again, exercises would be graduated in terms of length, complexity and number of parts.

- Look and imagine
  Exercises of the type 'what would this sound like….?'

  Students would be given prepared steps and asked to try to imagine and then clap (or tap on the computer keyboard) the rhythm that the given configuration might produce. The system could indicate whether or not the response was correct. This exercise would essentially introduce the concept of notation reading – students are required to abstract information from a symbolic representation and convert it to musical action.

- Rearrange the following
  Exercises of the type 'which ball would play this….?

  Students are given prepared sets of steps and experiment with different timbres to find the best combination. The object here is to gain some understanding of the role of the various percussion instruments in the context of a multi-part texture (e.g., bass drum on main beats, closed hi-hat in 1/8 notes, cymbals as occasional interjections etc)

In all of these exercises, stimuli would be presented aurally by the system. A feedback system will be built in so that students can hear simultaneously the 'test' sound and the result of their work, confronting them with any possible errors and hopefully encouraging them to fix any mistakes. A second level of help might be provided visually, by flashing incorrect steps or otherwise drawing attention to possible errors.

Technical issues

The initial version of DrumSteps was prototyped in Macromedia Director using the SourceForce extra, *SequenceExtra*, to handle MIDI outputs to quicktime/soundcard. In this form it is fully web compatible in both browsers, requiring only the free shockwave plug in from Macromedia and the SourceForce SeqenceXtra plug-in, also free. The current working version is implemented in Java and runs under both windows and Macintosh OSX. It requires no special hardware or software to run, with the exception of the Java runtime environment, available free from the Sun Microsystems website (http://www.sun.com/download)

Future Development

The DrumSteps software will be deployed and tested with children from January 2002. A networked version which will include a shared workspace and chat facility and data upload/collection to a server is in development, enabling children to collaborate remotely on joint composition projects. A drum interface is also in development, allowing children to input 'steps' using any standard drum and then further manipulate the musical material.

Conclusion

As with any learning tool, the value of this system depends on the use to which it is put. The system as envisaged would be flexible enough to allow the creative teacher to generate a range of different exercises aimed at encouraging the student to discover the various aspects of rhythm and percussion in a playful and exploratory way. The system should be open and flexible enough to allow for any rhythmic combination so that no limits are placed on the imagination and creativity of the child.

[i] C.Floyd Richmond, http://albie.wcupa.edu/schmus.mue/menu3.htm).

[ii] Papert, Seymour, 1980. *Mindstorms; Children, Computers and Powerful Ideas*, MIT Press, Cambridge

[iii] Granados, Rafael (2001), *Constructing Intersubjectivity in Representing Design Activities,* Journal of Mathematical behaviour, Vol 19, (4) 503-530

[iv]Kieth Swanwick, (1979), *A Basis for Music Education*, Routledge

[v] A particularly good example of this type of approach may be found at www.toysymphony.org, the website for the Toy Symphony project developed by Prof. Tod Machover and his Hyperinstruments group at MIT MediaLab Boston in conjunction with MediaLabEurope, CRITE and a number of orchestras, schools and childrens centers around the world.

[vi] Bamberger, J. (1981). *The mind behind the musical ear*. Cambridge: Harvard University Press.