

Introduction

Most art and music-making actively involves some type of electronic technology. Today, many theaters, concert, dance performance, and artistic installations use resources such as sound processing, video, live controllers, light design and synchronization systems. The demands of mastering a wide variety of such tools constitute a challenge faced daily by artists and producers – but this is not a new phenomenon. Many technologies have been adapted for use in performance settings almost immediately on emerging. For example, in 1881, only two years after Edison’s invention of the lamp, London's Savoy Theatre installed the world's first electric lighting system. Two years earlier, the famous cornet player, Jules Levy, was recorded playing “Yankee Doodle” (AES, 1999).

In this article, I examine the challenges involved in the types of technology classes common to arts education, exemplified by the pedagogical scenario associated with audio recording instruction. I propose to extend the use of *desktop simulations* as didactic tools, with the potential to address some of the pedagogical problems inherent in the teaching of arts technologies (e.g., a high learning curve with no “beginners’ aid” from the equipment; also limited student time in the studio and correspondingly limited freedom for experimentation). I show how recent visual programming languages

(VPLs) have made it considerably easier for instructors with an expertise in their subject area, but often with a limited background in programming to create software for educational use. And while desktop simulation helps to surmount immediate and practical pedagogical barriers, I also suggest that simulators possess the potential to democratize access to arts technologies, such as recording studios through lowered costs, elimination of space constraints, and reduced management requirements. Finally, because the simulators are geared toward individualized learning experiences, and thus lend themselves to education that meets the student at her own level of learning, simulators can aid in equalizing possible disparities in gender and experience level. A department's ability to offer tools and skills that will enable students to express a creative vision--the ultimate goal of arts technology education--may be more effectively achieved with the aid of desktop simulation.

Pedagogical and Technical Challenges in Audio Recording Studio Education

Since Pierre Schaeffer's first experiments with electroacoustic music at the close of the 1940s (Palombini, 1999), many theater, art, and music departments house their own studios, and recording studio techniques have been incorporated into music and arts curricula.

Today, the use and role of recording and audio technologies within academic institutions are wide-ranging. In some departments these technologies are used almost exclusively in support of the production of artistic works (e.g., the realization of sound tracks for theater department productions), while some programs and departments, such as music technology, sound design, or sound engineering programs, place technology learning at the center of their curriculum. As a result, most students and young professionals in these creative fields will have to deal with audio technology at some point during their academic careers and beyond.

Audio production and recording education contain large theoretical components. Topics like acoustics, electronics, programming and music theory are awarded varying emphases depending on each program's direction. These theoretical classes are usually taught in traditional classrooms, while more pragmatic instruction (e.g. signal flow, microphone allocation and mixing techniques) are normally taught in the recording studio. Learning theories, like Problem Based Learning or Discovery Learning, which employ the principle of Active Learning, have been attempted (formally or intuitively) in practical audio recording classes. These theories are developed under the constructivist paradigm, which promotes the creation of an environment wherein collaborative

exploration and experimentation are considered the main sources of knowledge generation. The implementation of these learning theories encourages students to produce their own ideas, solutions, and reflections.

Although it is easy to accept the relevance of the active learning approach to arts technology, four main difficulties can be observed when it is applied to a recording studio class: 1) cost of running a recording studio (equipment, maintenance, space and administration); 2) challenges in studio scheduling – because the studio is in much demand by both recording projects, instruction time in the studio can be scarce; 3) given the space constraints and the layout, the studio is not a very practical place to teach groups; 4) because some of the equipment is fragile and can easily be damaged by novice users, their range of use, and thus their experience and training, are often limited.

Given the considerable costs, space and administrative needs involved in running a recording studio, exposure and access to a proper range of equipment configurations can vary greatly among institutions. While some programs (for example, California Institute of Arts' Music Technology Program) are able to offer their students 24/7 access to studios, others (like UCLA Extension's Independent Music Production Program) don't even own studio equipment.

A regular recording studio is configured so that it may be

operated by one person at a time; one may make a comparison between operating a studio and driving a car. In demonstration lectures, the instructor first explains and demonstrates the procedure while the students observe. Because most studios are configured to facilitate recording, not lectures, often only some students in attendance will be able to see the demonstration properly. During a typical class period the instructor will normally have time to give a demonstration, but only a few students will be able to repeat the procedure. The remaining students will not be able to try the procedure with the assistance of the instructor and will often have difficulty reproducing the same procedure on their own. Thus, what would ideally be hands-on, practical classes become demonstrations during which most students merely observe, and only a few are able to apply what they've learned during a class session.

Where a department maintains one or more studios, intermediate and advanced students can commonly schedule personal studio time in order to work on their own projects. However, due to the difficulties mentioned above, most of the students arrive underprepared for their studio practice time. Notes taken during classes, user guides and textbooks constitute valuable help, but the extrapolation of this written information to a specific practice condition is difficult and time consuming. And the studio time is often spent less

than productively.

It is also an unfortunate fact that beginners might easily mess up the studio and even damage delicate equipment, causing many academic departments to choose to institutionalize restrictions on students' use of the facilities. In the interest of protecting the equipment and avoiding changes in settings that will inadvertently adversely affect the next user's time, it is quite common for departments to impose limitations on students' freedom to reconnect and reconfigure the system in ways that might be required by a particular project. If a student is allowed to reconfigure a recording studio freely, it is quite possible that she won't have the skills necessary to restore the studio to its default settings; thus, the next student will be forced to spend her studio time figuring out how the settings have been changed and attempting to reset them.

Even in an ideal situation with enough available studio time, the ability to configure the studio according to each student's needs and to provide a wide variety of equipment would not automatically guarantee a desirable educational situation. When beginners are given the opportunity to practice in a studio, they can spend hours, say, attempting to figure out why they are unable to hear the sound of a CD they may be playing from a playback device. There are few clues inherent in the equipment itself that might guide or alert the user as to

where to start troubleshooting. A basic studio setup (microphone, playback, mixer board, recorder, amplifier, speakers) offers hundreds of possible connections and as many places to troubleshoot.

Configuring the simplest setup in a professional recording studio (for example, monitoring a microphone) requires nearly twenty steps. A regular work scenario, such as recording and mixing a rock band, demands around a hundred steps.

When we take into account the practical limitations on studio access and on the ability to work freely with studio settings, along with the high learning curve that often hinders students' ability to take advantage of their studio practice time, we can see the difficulty in implementing the constructivist paradigm under traditional audio recording studio circumstances. Even if educators of audio recording technology know--as DePlachett reports that Brown, Cocking, and Bransford have outlined in *How people learn* (2000)--that "human beings learn most effectively when they: (1) construct meaning by attaching new knowledge to exiting schema ...; (2) engage in opportunities for self-exploration, self-expression, and non-linear investigations; and (3) acquire and adapt the protocols and procedures within disciplines and program areas, moving toward growing proficiency in transfer and independent use and application" (DePlachett, 2008), it may be difficult to develop a pedagogical

strategy according to this schema while using only the physical recording studio.

Simulation as a Solution

Although we need to refrain from over-generalizing solutions, computer simulation could help solve some of the challenges discussed above: cost and access; integrating theory with practice; one-driver situation; protecting equipment; range of equipment offered; high learning curve. Uniquely able to “store, deliver, and help manipulate a variety of symbol systems: visual, acoustic, textual and numerical” (Koehler and Mishra, 2008), computers and their application systems have been used to extend human power. Computers allow people not only to do things they couldn’t do before, but also to engage in familiar procedures with greater ease (Papert, 1980). Computer simulations, specifically, are used extensively in industry for product and production design and in the sciences to visualize theoretical and mathematical models on micro- and cosmic scales. In addition, computer simulation has been utilized in conjunction with constructivist learning theories in several educational fields to simulate equipment, devices and conditions when a procedure is too dangerous, too expensive, or simply not realistic to implement. We may find examples of this in military training (The VR-Forces application allows scenarios to be built by positioning forces); medicine (Gas Man, a

computer tool for teaching, simulating and experimenting with anesthesia uptake and distribution); electronic engineering labs (CADENCE, electronic lab simulator for professional and educational applications); and mechanical design (Carsim in the classroom, designed for professors in teaching vehicle dynamics, chassis development, and controls classes). Significant advancements in the development of virtual reality environments have also been seen in psychotherapy where simulation is used to help the patient in dealing with phobias or traumatic situations, where the simulation allows the patient to gradually approach something that is perceived as threatening (Virtually Better).

Computer simulations include three main categories: text-based (MOO Diversity University); desktop, or non-immersive (flight simulator); and immersive (NCARAI-Gaiter) (Javedi, 1999). For the purpose of audio recording pedagogy, the more realistic virtual representation the better. However, until now, fully immersive virtual reality simulation has been extremely complicated and has required expensive and specialized hardware that would return us to the original problem. Other than a basic computer, desktop simulation doesn't require any specialized hardware; it may be compared to an advanced version of multimedia with real-time interactivity. (See a taxonomy of the major commercially available simulation tools in

Chapman, 2008.) The costs associated with its implementation are therefore relatively reasonable. Desktop simulation can represent a wide range of objects and situations, from a simple electronic circuit to a virtual world like Second Life. Even in a two-dimensional environment, the simulation would allow the user to interact with and learn the procedures involved in using specific pieces of equipment and interact in virtual work scenarios with visual and audio aids, tracking progress and all of the tools native to computer application aids.

While existing simulation software used training within medicine, engineering, and military has proved effective, and while there are enough similarities between the pedagogical needs of such education and arts technology education, simulation development companies have offered fewer products in this field. However, with the current computing power and graphical capabilities of personal computers, combined with the development of new Visual Programming Languages (VPLs), the tools available for instructors of media arts to build their own desktop simulators are powerful enough. Because VPL languages are very intuitive and graphically oriented, they allow a person with no prior experience to write applications, from simple to complex. VPLs like Alice or Microsoft Robotics Studio are even promoted to teach the user the fundamentals of computing programming. Specifically, VPLs, such as Max/Msp/Jitter and Pd with

already embedded audio and visual tools were designed by and for sound researchers and artists. The freeware Sim-av (simulators of audio and video equipment) is an example of the use of a VPL by a person with no formal background in programming. Luis Fernando Henao, an instructor of sound engineering in Colombia, developed this 2D simulation of audio recording studios using the Max/Msp.

Discussing challenges related to the integration of technology in pedagogical content knowledge (PCK), Matthew J. Koehler and Punya Mishra recommend that a “greater emphasis should be placed on the idea of teachers as ‘curriculum designers’” (2008). I would add that it may also be necessary, as in Henao’s case, that a greater emphasis be placed on instructors as designers of the learning environment – aided by technology such as simulators. This notion aligns with Koehler and Mishra’s emphasis on “teacher knowledge” and their view that teachers are “autonomous agent[s] with the power to significantly influence the appropriate (or inappropriate) integration of technology in teaching” (Koehler and Mishra, 2008).

Simulation for educational purposes is currently having a significant impact on practice and research-based educational fields. Some academics have been more cautious than others, and some see simulation technologies merely as money-saving strategies (Moura, 2000). Even instructors who are very enthusiastic will sometimes get

discouraged by the time and effort that implementing new technologies may require--simply put, that computers can be difficult to learn--or by what Koehler and Mishra (2008) have described as "technology and its complex role in teaching." Despite the fact that there is a need for a larger variety of studies, many have already demonstrated the significant benefits of the use of computer simulation in education (Javidi, 1999).

Simulation is cost-effective, safe, and encourages student exploration and research (Ausburn and Ausburn, 2004; Javidi, 2008). In the case of audio education, with a recording studio simulator, classes can be taught in computer labs. Unlike a conventional studio demonstration, each student will be able to follow the lecture from a projection and execute the requisite steps from their own computer workstation. Students and instructors can also install the simulator on their own computers and exchange work sessions by email. With the studio simulator, students can connect and disconnect the virtual jacks, manipulate the audio in real time, and follow tutorials and virtual work.

During a typical class using the simulators, the instructor might move around the classroom computer by computer, offering help to individuals. Every student working with the Sim-av simulators can upload their own music and create their own mixes. They can also

save their work and resume it later. Students can share experiences by making their sessions available electronically. Using a recording studio simulator, a student can send her own studio configuration to the instructor. Seeing the student's configuration makes it easier for the instructor to understand where the student may be struggling and then provide feedback. Simulation as a pedagogical tool offers not only a simulated version of the relevant hardware, but also multiple pedagogical possibilities unavailable in a hardware situation. Besides the didactic benefits described here, simulation systems could be fertile ground for developing embodied curricula, as described by Sasha A. Barab and Tyler Dodge (2008), moving toward abandoning didactic modes of lecturing in favor of experiential or situations models of instruction.

These factors indicate that the desktop simulation technology may be more effective in the transfer of *technological pedagogical content knowledge* (TPCK), what Koehler and Misha (2006) have described as "a framework for teacher knowledge for technology integration." Referring to a study by Veerman and van Joolinen (1998), Sabrina Graf and Kinshuk (2008) posit that "simulation-based discovery learning results in deeper rooting of knowledge, enhanced transfer, the acquisition of regulatory skills, and thus better motivation."

In addition, simulators can also help students avoid the stress that public exposure in technology classes can generate. Technology classes in which students are expected to demonstrate a procedure for the class can cause a high level of anxiety based on a variety of factors. Gender stereotypes in technology education--in this case the stereotype that men are better suited for recording engineering--is a factor Jo Sanders has investigated. She concludes that women's anxiety about failing in a computer situation can affect the performance and actually *reinforce* the stereotype (Sanders, 2005).

Conclusion: Desktop Simulation as a Democratizing Tool

Because the cost of purchasing, maintaining, and updating proper equipment is prohibitive for many institutions, a gap increasingly yawns among institutions' abilities to offer, on the one hand, a comprehensive education requiring expensive equipment, and, on the other, a greatly limited education in areas with fewer resources. Young people who attend institutions with few resources emerge both under-qualified to support any of the country's electronic art or music industry and unable to realize their own artistic visions. We can envision the possibilities engendered by emerging capabilities, such as cloud computing, which can host a simulation system and make it available through online classes or as a supplement to a regular class. With such an arrangement, the same simulation system could be made

available to institutions with few resources. Such an infrastructure would allow and encourage participants to interact with colleagues beyond campus borders, and beyond the intangible borders that often coincide with class, ethnic groups and geography. Nancy DePlachett (2008) has noted positive effects when teachers connect online with students, and when students form communities with peers located in different parts of the world. While they are learning the subject at hand, DePlachett remarks, these students can also “simultaneously [learn] about other countries, cultures, and methods of art making” (DePlachett, 2008).

Although arts technology has always been a hands-on discipline, inherent challenges have prevented even those students who had access to studios from taking full advantage of this pedagogical strategy. Computer simulation in arts technology education provides pedagogical options not offered by hardware versions of the necessary equipment. Simulation can therefore aid in addressing what seems, with hardware versions of the studio, like a huge gap between theory and practice. Because of its cost effectiveness and availability to anybody with a basic computer, simulation also helps to bridge the gap between education in institutions with differing levels of resources and in disparate areas of the world. Thanks to visual programming languages such as Max-Msp,

it is realistic that instructors with no prior programming skills will undertake the task of creating custom-made simulations that may then be shared.

And, as with any skills learned within the arts, the skill itself is not the objective. Simulated learning environments offer the capacity to meet students at their individual learning levels, and thus invite them to feel comfortable in drawing on previously-acquired knowledge. The confidence thus engendered, and the associated fluency and comprehensive knowledge of overall processes involving, for example, the signal flow in an audio recording environment allow a young artist to feel not only free to, but also *able* to experiment and express themselves – which, for most arts educators, is an aspiration.

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