Computer-Based Technology and Music Teaching and Learning: 2000-2005

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> What is needed is a scientific investigation project and a music-specific technology assessment of the degree of change caused by computer technology in all forms of musical production, behavior, and views about music and music production. (Enders, 2000, p.235.)

Writing as part of a seminar on technology and music in Budapest some 15 years ago, German scholar Bernd Enders articulates a wish that, at least on the surface, seems natural enough. Unfortunately, such a project is not likely because of both the vastness of music technology and its many applications across the music enterprise and because stakeholders never seem to agree on what constitutes acceptable degrees of change.

Perhaps such a project is not necessary. Practical evidence abounds about the quality and quantity of change brought about by music technology in the production and certainly the consumption of music. Music notation software is now so commonplace that the thought of submitting scores for eventual publication that are hand written seems horribly dated. In terms of the recording, preserving and editing audio, advanced digital systems dominate all phases of production. Even the distribution of music in this iPod-dominated age of the Internet has blossomed overnight.

However, for those in music education charged with the responsibility of preparing children for a world of music experiences, the question of degrees of change is more troublesome. It seems so obvious that music technology must play a role in music teaching and learning, if nothing more than to prepare children for music production and consumption.

> . . . we can take a piano lesson with a live teacher on the web who can hear us play at the same time we play and can talk with us about our

> performance in a way that is not dissimilar to what a piano teacher might do with your son or daughter who lives only a couple of blocks away. . . Computers make it possible for people who have little or no knowledge of traditional theory to compose music…music programs must now provide training in technology. (Roberts, 2000, p 7.)

Large costs are incurred by equipment and software, to say nothing of the hours of teacher-time in learning the technology and planning for its use. Policy makers must be as sure as humanly possible that such costs are expended wisely. It is also clear that professionals are less interested in comparative studies that pit music technology against "regular teaching" since the data are clear that, at least for lower-level skills and knowledge, technological approaches do equally well or better than more conventional teaching. What is of more interest is the nature of the complex interaction of variables that are in play surrounding the learning of music as art and how this fits into this mix.

The purpose of this chapter is to offer a summary of literature in music education and technology in the last five years that helps to explain these interactions. The chapter builds on the reviews already published (Higgins, 1992); (Berz & Bowman, 1994, 1995); (Walls, 1997); and (Webster, 2002). Using the basic design of my 2002 review which covered the majority of work from 1990 to 2000, I begin this chapter with a background section on previous research summaries and a section on forces that effect the literature, including status studies and conceptual writing. The section also includes a brief accounting of a few major practical articles that feature computer-based music technology for education. The remainder of the chapter summarizes research on topics relating to K-8, high school, and college/adult levels of instruction. The chapter ends with summaries of research on additional variables such as attitude and self-efficacy, as well as a section on distance learning.

Background Writings

Previous Reviews

Higgins (1992) summarized well the classic problems with research on music technology, including poor design, inadequate treatment, and the confounds that the

changing nature of technology bring. More importantly, he argued for a change from simplistic studies that pit music technology itself against traditional instruction to a more complex design that considers context and individual differences in students (p. 491). More complex designs have followed in recent years and this is a welcomed change (see studies by Mills & Murray, 2000; Addessi & Pachet, 2005; Hopkins (2002); Stauffer, 2001; Seddon & O'Neill, 2003; McCord, 2002; Pitts & Kwami, 2002); Walls, 2002; Reese, 2001; and Bauer, McAllister & Reese, 2003).

The Berz & Bowman (1994) monograph highlighted the relative neutral to modestly positive findings of experimental work and this is also noted in current research reported here. The trend toward generally positive attitudes toward music technology in both teachers and students compares favorably to much newer work on this topic summarized in the concluding pages of this chapter.

Forces that Shape the Technological Climate

In my last review, I made the case for three major forces that shaped the literature: rapid technical development of hardware and software, the ubiquity of computer-based technology, and the continued endorsement of constructivism as a philosophical approach to teaching and learning. All three continue to prevail, but they are recast below in slightly different terms. Each has had its role to play in the kinds of questions researchers ask.

Internet Use. Certainly computer hardware has improved still further in speed and power while dropping in cost. Laptops are the most popular type of computer purchased today and personal digital players like Apple's iPod, are among the most popular digital devices purchased by today's youth. Music software titles continue to grow in number and functionality, with digital audio software among the most pervasive (Williams & Webster, 2006).

Certainly these developments continue to drive the practicalities of technology in the schools, but the rise of meaningful Internet-based resources is worth special note—especially in terms of how society is now beginning to use the Internet as a major way to consume music (Field, 2001; Latonero, 2003). The Internet as a resource for K-12

education in general is only beginning to be studied systematically but early evidence is promising, especially if the instruction is well supported by teachers. Barry (2003) studied the integration of web-based material into graduate music research teaching, documenting phases of integration that included supplemental links to resources, web-based teaching sequences, and various media to support course content. Data sources included journal and field notes, student work, and course evaluations. Students had positive attitudes about the web-based instruction and felt it improved the course. Ryder (2004) completed a study of Internet-based teaching strategies for instruction in vocal anatomy, function, and health with high school choral students. He reported statistically significant gains between pre- and post-test scores on attitude and achievement with over 200 students at three different high schools. Distance learning initiatives in music are growing and are summarized in the closing pages of this chapter.

Status Studies. Music teachers seem to use technology more for administrative tasks as opposed to music curriculum uses (Taylor & Deal, 2000). This trend was supported in more recent times by Jassmann (2004) and Ohlenbusch (2001). Price and Pan (2002) reported results of a survey of college music education degree programs in the southeastern United States. Of the responding institutions (n = 69) in states such as Florida, Georgia, Tennessee, and six others, 39% state that they had one to three technology courses for music education students and 64% reported having at least one lab for music education technology. All responding institutions, except for one, indicated that knowledge of music technology was vital.

Metlzer (2001) completed a well-designed study of entering music freshmen in five, randomly-selected, publicly-supported schools of music in the mid-western United States. Three-hundred and eleven freshman completed a survey (83% return rate) that sought to determine student experiences of, skills with, and attitudes toward technology. Also of interest were the relationships between these variables and demographics and uses of technology by students' high school teachers. Findings suggested that the vast majority of entering freshmen music majors have experience with word processing software (97%) and with other non-music applications such as e-mail and spreadsheet

(20%-46%). Use of music software was generally lower, with roughly a third of the sample having some experience with music software of various types.

Finally a study concerning the quality of music technology integration in the schools was reported from the United Kingdom (Mills & Murray, 2000). Based on an inspection of actual music teaching in 52 middle schools in England, data was provided about the overall rating of lessons and particular details about how the technology was used by the music teachers visited. The point of the survey was not to report about music teaching from a random sample of schools, but to study already identified "good music teaching" schools in order to identify the nature of music teaching using technology. What is noteworthy in this report are the summaries of detail about what constituted a "good" music lesson among the 106 lessons rated highly. Descriptions of how the teachers used computers for composing, performing, and many other music behaviors are offered in the report, based on the inspection of lessons at the schools. This level of description across many schools and music lessons is rare in the literature and should be replicated.

Conceptual Writing. One might imagine a powerful conceptual base that drives research in music education technology, however we continue to lack thoughtful writings that do this—particularly from a philosophical perspective. The warnings by Healy (1998) of the improper application of technology in schools continue to inspire some writing by music educators. Upitis (2001), a clear advocate of using technology in music teaching settings, worried about the blind acceptance of technology in the schools and likened the endorsement of technology to the wrongful claims of the power of motion pictures to change education in the 1920s. (p. 48)

Beckstead (2001), in an article on transformation of music education by technology, suggested that technology plays not only an efficiency function but also a transformative one. Increasingly, more conceptual writing about the role of music technology points to its power to re-conceptualize the traditional roles of composer, listener, and performer. This is especially true for the compositional experience because of the ability of individuals at a very young age to manipulate sound and create compositions with hardware and software resources.

There continues to be strong interest in framing music technology in a constructivist context. Keast (2004) used constructivist techniques as a philosophical basis for an on-line graduate music education course. He studied the way students used the technology in preparing for a class presentation and the results were judged to be modestly successful.

A more extensive application of constructivist learning theory can be seen in the work of Buehrer (2000). Writing about the teaching of aural skills on the college level, he documents the history of constructivist thinking and describes how this approach can be applied to an aural skills curriculum in college by presenting a mock textbook unit that might be part of a typical theory sequence. Music technology plays a major role in this unit by offering students the tools to explore music theory and aural skills in a exploratory and problem-based fashion rather than the more traditional, teacher-centered approaches. Buehrer creates an excellent conceptual base for how technology plays a role in the recasting of traditional music theory pedagogy. Such writing should serve as an inspiration for systematic research.

Practical Writings

An important part of the background for research are the contributions to the literature on practice. Space prevents an extensive review of this work, but some comment on the more impressive writings in this category is necessary. Each of these contributions to the literature provides important direction for focused research on technology's role in music education.

Teaching Strategies. Reese, McCord, & Walls (2001) published an important compendium of teaching strategies in music technology tied to the National Standards for Arts Education. Appropriate for all levels of instruction, the book contains a number of examples of music technology applications in performance, composition, and general music settings. Bauer (2003) edited a series of focused articles on music technology application. Articles in the series include writings on web resources that address the National Standards for Arts Education, music composition in the schools, the digital piano, and music notation software.

Composition. Reese (2001) offered special perspective on the use of technology for composition and improvisation geared toward the notion of "thinking in sound." The article reviewed software that helps accomplish these goals and provides a list of teaching strategies that can be used at different instructional levels. Siegel (2004) chronicles a composition project for third, fourth, and fifth grade students. The work was noteworthy because he engaged the class to do this with only one computer, a MIDI keyboard and, a TV screen. Using student-designed poetry as a start, the article describes the process of group creation.

Performance. Helpful articles on integrating technology in creative ways into performance instruction continued to be published. Fautley (2002) provided a number of interesting ways to extent the band experience in schools by using technology with home computers. His suggestions include the exchange of audio files with email commentary, the use of mp3 files for supporting home practice, and submitted recordings as evidence of practice. Reid & Petocz (2001) provided a description of a multimedia program designed to encourage ensemble performance. Five contemporary compositions for recorders were created for this project and the multimedia experiences (video, notation, graphics, text) based on these compositions engaged the user in experiences (some reflective) that helped to teach ensemble playing.

Assistive Technology and Music Therapy. During the last five years, the music literature on the use of technology in assistive ways has increased. Gregory (2002) wrote a review on such uses of technology in computer-based music instruction. The article contains a review of resources and information that can be used to help those with vision and hearing difficulties, as well as dexterity problems. Contact information is provided, together with reviews of important legislation about serving those with special needs. Crowe & Rio (2004) published an important review on the use of technology within music therapy practice. The review included data from published sources and an extensive interview of practitioners.

Music Listening/Aural Skills, Performance, and Composition

This section and the ones that follow include summaries of empirical work, both qualitative and quantitative, in music teaching and learning since 2000 that addresses music technology directly. This section deals with the music experiences of listening, performing, and composing. Other sections deal with related topics of importance to researchers since the last review.

Music Listening/Skills Development: K-12

A study on preschool children's interaction with music technology was reported by Addessi & Pachet (2005). This study is one of the first to be published that deals with three- to five-year-old children interacting with technology of this sort. Using an interactive, computer-based music system called the *Continuator* that interacts with a piano keyboard, children can perform short gestures on the piano and have the computer-based system answer back with a gesture that is based on the child's. The study included video-based observations of 27 children interacting with the system singularly and in groups of two. Tasks included working just with the keyboard and with the echoing interaction activated. The researchers also collected drawings from the children based on the experience and solicited questionnaires from the parents about musical taste and experience of the children. The study reported general trends for how the children interacted with the system and presented two case studies that explore the interactions in depth. The study's results were more about improvisation and creative interaction and less about the technology, but what makes this study important for this review is that the technology made possible levels of analysis not readily noted before.

Greher (2004) used a multimedia program with middle school students to encourage music listening. The program presented alternate music sound tracks to movie clips, encouraging students to make decisions about what were the best matches and why. In addition to provided music, students could create their own music and hear the original tracks meant for the films. Participants from three inner-city classes participated in the study, including certain bilingual students thought to be at-risk. The point of the study was to encourage critical listening, group decision making, as well as collaboration and literacy. Attitude surveys were used as evidence. Qualitative data from field notes based

on observations, teacher interviews, and the opinions of the students themselves were considered. Results suggested that the software created an environment that succeeded in encouraging active engagement with the music and deeply held convictions about the role of music.

Music Listening/Skills Development: College

Non-majors: Music Appreciation. Piccioni (2003) reported on a qualitative study that investigated the use of digital technologies in such classes. Standalone programs and Internet resources were considered. Results indicated that the instructors felt that such resources were effective and worthwhile, but that each instructor had to deal with technical difficulties and personal growth in their understanding of technology.

Music Majors. Hopkins (2002) used customized music software to investigate the effectiveness of two instructional approaches (expository vs. discovery) on the ability to recognize different types of theme and variation categories. The researcher created two versions of the same software program and varied the instructional content. The expository approach presented the definitions of the different variation categories (ornamental, figural, modal, and tempo) in straightforward terms with examples and explanations. The discovery approach withheld the name of the variation category and encouraged the students to intuit the type from examples and explanations. Hopkins was interested in the effectiveness or each approach by evaluating scores on a dependent measure of variation understanding. The design was a classic experimental one with controls for music aptitude and prior knowledge of the variation categories. The dependent measure was an aural test of identification of variation types. Another version of the test was given after 6 weeks to gauge retention. Results showed no significant difference in methods of instruction on the post-test measures immediately following use of the software and after a 6-week interval. Each method was equally effective; however, variations were seen in the time taken to use the software (more time for the discovery method) and there was more individual variation in performance for the discovery method group. This research is noteworthy because it did not simply evaluate

technology-based versus classroom instruction, but studied different approaches to the use of technology.

Walker (2001) completed a qualitative study of Internet-based journaling in a Schenkerian analysis class for graduate students. Data was collected during participant observation and included bi-weekly questionnaire data and final private interviews with each student and the instructor. Emergent issues were identified, including differing perceptions about the class experience between the students and the instructor. Collaboration included joint analyses of music and critiques of each others writings. Conclusions were that such computer-mediated communication was beneficial to learning and that such approaches can play a valuable role in graduate education.

Quesnel (2002) evaluated the effectiveness of music software to enhance memory for timbre, sensitivity to timbre change, and disciplined auditory attention and efficiency. Working within the context of professional-level audio engineering, the researcher employed computer software in combination with individual tutoring sessions with student subjects that had little professional experience. He compared this student group with experienced, professionals involved in sound recording and post-production on an index of skills related to the variables of interest and noted that the students who used the software and tutoring out-performed the professionals.

Performance/Conducting: K-College

Smith (2002) completed a study of the use of computer-assisted instruction and its effect on the development of rhythm reading skills with middle school students. Also of interest was the cognitive style variable of field independence/dependence (FDI). After controlling for FDI, students were assigned to a control vs. experimental group with the experimental students receiving instruction on rhythm reading using the software *Music Ace*. Post-test scores on a measure of rhythm reading skills did not show a significant difference between groups but each group gained significantly from pre-test to post-test. Field independent students did perform better on the post-test than did field dependent students. Student attitudes were very positive about the use of the computer-assisted software.

Green (2003) studied computer-assisted instruction as an effect on guitar performance achievement and general music achievement. He also included groupings for high and low music aptitude as measured by a test of audiation. The *Interactive Guitar* software was used in this study. No significant difference was found after five weeks on the music aptitude or guitar performance measures. Students that scored highly in the audiation measure also scored better in music achievement and guitar performance.

Interest in intelligent accompaniment continues. Glenn (2000) studied the use of the *SmartMusic* intelligent accompaniment program with students in applied oboe, clarinet and bassoon instruction at the college level. Control and experimental groups showed no significant difference when the intelligent accompaniment program was used in experimental treatment. However, scores were higher for the experimental group and students in that group indicated on a questionnaire that they enjoyed the intelligent accompaniment software and that it contributed to their musicianship.

Two studies were published on the role of technology in college-aged piano students. Benson (2002) studied the effects of instructional media capable of providing audio, video, and multimedia models on group piano student performances and attitudes when used in student practice. Results of a measure of final performance tempos and note accuracy showed no differences across groups. Sample size was small (n=16) so it was difficult to have great confidence in the findings.

In terms of fundamental conducting skills, Kraus, Gonzalez, Hill, & Hemphreys (2004) studied the effects of two types of instruction, computer-generated musical feedback and verbal instruction. Undergraduate music majors (n=52) were divided into 3 groups, including a (no-instruction) control group. The experimental group received conducting instruction using the Digital Conducting System (DCS), an interactive real-time computer music system that played musical etudes in response to fundamental conducting gestures. The device used two electromyography signal-conditioning electrodes attached to the arm of the conductor. A second group received verbal instruction with no technology. Video-taped evaluations of students on post-test skills tests revealed significant gains for one of four skill tests in favor of the DCS group.

Composition: K-8

The literature on music composition continues to profit from researchers using music technology to great advantage to allow students to think compositionally. Stauffer (2001) published qualitative work with one of her young composers—in this case, Meg. Stauffer begins by chronicling her joint development process with Morton Subotnick in the development of the *Making Music* software that was so instrumental in Stauffer's work. The remainder of the study describes in some detail the observations of Meg as she worked with the composition space in the program. Making Music uses a drawing metaphor for creating musical structures. The software allows for manipulation of timbre, tempo, texture, pitch space, and many other musical manipulations—all using the mouse-controlled cursor as a pointer. The software allows for the user to save compositions to a "Composition Book" space in the software. Throughout the study, the composition process is described for Meg in ways that make clear the power of the computer software to allow this kind of analysis.

Seddon and O'Neill published two studies (O'Neill & Seddon, 2001; Seddon & O'Neill, 2003) using computer-based compositions by children. The first study evaluated compositions by children (aged 10 years, n= 32) with and without prior experience in music study. The music was evaluated by music specialists and non-music specialists, the children themselves, and expert evaluation of rhythmic and melodic repetition and development. Technology used was a clever adaptation of a simple sequencing program so that students with and without musical experience could create a music composition "that sounded good to them." The adaptation presented some restrictions on timbre and composition length. The technology allowed recording the compositions for later analysis.

The second study used the same approach with a modified sequencing program, but used the computer to record student compositions in process. Students were 13-14 years of age (n=48). This study's focus was on the creative thinking processes and the strategies adopted together with the influence of instrumental music training. With the use of a special video card, the composition sessions were recorded unobtrusively. Music in the form of MIDI files were routinely saved at key times and this allowed the

researchers to study the music together with the video tape record of gestures. Technology of this sort is especially useful for studying real-time processes such as these.

Nilsson & Folkestad (2005) reported on a two-year empirical study of nine eight-year-old Swedish children composing music with a synthesizer and computer software. As with Seddon & O'Neil, MIDI files were collected systematically over the composition process development. As the researchers state:

> The synthesizer and the computer software represent powerful tools, which facilitate the participants in expressing their musical ideas without being formally trained in music. The digital tools used by the children represent a medium where planning, improvising and elements of contingency coexist. (p. 35)

Finally, in this age category, McCord (2002) reported a study on children with special needs composing with music technology. In this observation study, the researcher used video tapes of compositional process, student interviews and reflections, the student compositions themselves, and on- and off-task behavior to evaluate how the children used the technology. Elementary-aged children participating in the student had various special needs, including learning disabilities. Technology used included specially designed software and commercial programs such as *Music Ace* and *Making Music*. The specially-designed software, *Music Mania*, records all MIDI data created by the children and also allows children to write reflections on their experiences. The study gives several descriptions of children and documents their use of the software so that other educators can gain an understanding of how to use technology in special settings. McCord argues that the technology provides an often-needed, multi-sensory approach to learning that is most valuable to special needs children.

Composition: High School

Kennedy (2002) reported work with high school composers. Her work was similar in spirit to Stauffer in that she was most interested in the compositional processes of students. She focused her work on four high school students, two with strong

backgrounds in music performance and theory/notation and two less experienced. The two tasks involved setting a poem to music for acoustic instruments and a free-designed composition using computers with attached MIDI keyboards. "Audio journals" were used in the form of cassette tape recordings to record work sessions which served, in part, as bases for interviews with the researcher. A CD was made of the final compositions and notated scores with created. Students spent more time on electronic pieces than on the acoustic task. Kennedy stressed the importance of music listening in her student profiles.

Pitts & Kwami (2002) summarized the results of a set of focused interviews with students and teachers in eight schools following questionnaires on this topic from 18 schools in southeastern England. The study was important because it documented the difficulty faced by teachers new to technology and its integration into teaching and learning. The sociological, economic, and pedagogical pressures that teachers face are documented in the study and some questions were raised regarding the tradeoffs between teaching technology as opposed to teaching music. Technical problems with the equipment and software were reported as a frustrating part of using technology in schools, but the study did demonstrate the "…opening up of avenues of exploration: composing music pupils could note play reliably themselves, performing music with a control of detail not possible in 'live' music, and listening to the merits of live and sequenced versions of a song." (p. 70)

Savage & Challis (2001) published a report that documented the use of short sound recordings and digital audio, multitrack software to create a piece of original music to commemorate a town in England. This was a multi-class project involving several students and their recordings of speech and environmental sounds as well as instrumental and vocal sound sources. Group collaboration was used to choose sound pieces to include in the composition. Mixing and re-mixing techniques were used in various aspects of the project. The authors report strong feelings of ownership by the students of the final products. In a more recent study, Savage (2005) reprised the results of this study and added perspective from two other composition projects using technology.

Distance Learning

Readers are referred to the excellent chapter by Rees (2002) that summarizes the distance learning movement in music and music education. A recent meta-analysis of the effectiveness of distance learning in the general literature (Bernard, Abrami, Lou, Borokhovski, Wade, & Wozney, 2004) is informative but inconclusive in terms of comparative data; however, serious work in distance learning in music education is just beginning, and the results seem intriguing if not promising.

For example, two research studies that use the Internet for mentoring include work by Reese (2001) and Bush (2001). Reese investigated the feasibility of integrating on-line mentoring of music composition into course for music teachers by asking 17 university students (University of Illinois) to mentor 43 middle and high school students (Chicago suburban schools). The subject was music theory and composition using technology. University and secondary school students had experience with music technology and the Internet prior to the study. Mentors (university students) were paired with a middle or a high school student with the responsibility of helping the school students with music composition assignments. Music files were exchanged as were emails about the music. Data included surveys, written assessments by and interview with the university students, review of exchanged data, and other data sources including attitude assessment. Results suggested that mentoring of this sort is feasible and improvement was noted in university student feedback abilities and attitudes. The influence of the mentoring on the students was less clear because return dialog from the students to the mentors was not as forthcoming as expected.

Bush (2001) reported a similar mentoring project with the Internet, but between music teacher education students and with practicing music educators. Each teacher education student (Arizona State University) was teamed with three or four professionals in the field (mentors) from different regions of North America. Weekly questions were asked of the mentors and answers were discussed on campus in group meetings with the students. Mentors also were asked to suggest a question or problem to be discussed on campus and the results emailed to the mentors. Anecdotal and formal data from the study indicated that positive effects on both the mentors and the students were realized.

Distribution of audio over the Internet for music instruction within restricted domains such as college campuses is now common place. Griscom (2003) summarized this development for college libraries. The article reviews digital audio preservation projects, streaming of audio, and copyright issues. The effectiveness as an approach to teaching music in various class settings has not been researched.

Video conferencing with high quality sound is a very promising recent development. Eberle (2003) has contributed a review article on the possibilities of video conferencing and web-based instruction. She reviewed technical issues for establishing connections for music teaching, including dedicated ISDN lines and the newer approaches that use the Internet only. In that regard, Winzenried (2002) writing in the Symphony magazine of the American Symphony Orchestra League, documents the growing interests in partnerships between institutions like the New World Symphony in Miami and music schools like the Manhattan School of Music and the National Arts Centre in Canada using Internet2[1] capabilities. Systematic research on the effectiveness of these video conferencing experiments await completion.

Finally, the rise of complete courses of instruction and entire degree programs in music and music education are now more commonplace. Little or no research exits as to the effectiveness of these courses and degree programs.

Additional Topics

Attitude, Self-Efficacy, and Self-Concept

In this final section, I review three additional categories of research that have emerged in the last five years. Issues of student and teacher attitude toward the use of technology in teaching are investigated as secondary concerns in many of the research studies reviewed above. Several studies published recently have concentrated primarily on attitude as well as feelings of self. Ho (2004), for example, found high levels of confidence among boys and girls for using the Internet and music technology in Hong

[1] Exchanges like this are made possible by the Internet2 initiative. Internet2 is a consortium being led by 207 universities working in partnership with industry and government to develop and deploy advanced network applications and technologies over high broadband networks.

Kong schools. Primary school children seemed more positive than secondary and few gender differences in attitude were found.

In a far different population studied, Legette (2002) investigated the effect of technology-assisted music instruction on the general dimensions of self-concept such as behavior, intellectual and social status, physical appearance and attributes, anxiety and happiness and satisfaction. The sample included 119 fourth-grade students in two predominately African-American populated schools in a high crime area of the southeastern United States. A pre-test/post-test design was employed with a control group that did not receive technology-assisted instruction in music. After a 17-month period of instruction, no difference in general self-confidence scales were shown, however academic achievement in language skills showed a significant gain.

Airy and Parr (2001) using semi-structured interviews, found New Zealand tertiary students' attitudes toward the use of MIDI sequencing software to be generally positive, particularly because such software gave a voice to those previously excluded from composition. The quality of MIDI sound was an issue because of the lack of realism and certain keyboard controllers were thought to be inferior.

Bauer (2001) investigated attitudes toward web-enhanced learning in a music education methods class. General attitudes toward this instruction was positive, but did vary somewhat based on whether the student had a home computer and what the nature of their past experience with web-based learning. In an effort to study gender differences and classification (graduate vs. undergraduate) in attitudes toward electronic journaling about reflective practice, Bush (2004) found that graduate students demonstrated more favorable attitudes toward electronic correspondence. Female students showed more favorable attitudes as well.

Walls (2002) completed a pilot study on the use of a hypermedia program on music compositions performed within the context of band choir ensemble. Of interest were the attitudes of the middle and high school participants toward the use of the technology to enhance comprehensive musicianship. Results indicated generally positive reactions to the integration of this kind of multimedia into the rehearsal setting. Of interest in this study was the inclusion of teacher-education students as observers and

participants in the instruction, thus modeling the use of technology in real-life music teaching settings in the schools.

Glenn & Fitzgerald (2002) studied attitude, motivation and self-efficacy amongst college-level applied music students and their use of the computer-based accompaniment software, *SmartMusic*. Comparing questionnaire results between groups of students that used such accompaniment software versus a group that did not revealed that students in the accompaniment software group felt that their overall musicianship improved because of the software and that the technology was most effective in terms of repetitive practice.

A recent study by Barry (2004) investigated college-level students' comfort with the use of technology in the schools. Results revealed that students rated themselves as needing training in higher levels of music technology knowledge such as the creation of web pages, using a music editor, and using music education software. The study used a well-designed, self-evaluation measurement tool for assessing technology skills.

Fung (2003) and Bauer (2003) completed separate studies with pre-service teachers. Fung studied gender differences in familiarity with technology and Bauer evaluated both gender differences and ratings of computer self-efficacy. Fung discovered that there were few differences in the ratings of familiarity between male and female in terms of types of technology applications (n=135). Bauer collected data from 114 college-level music education majors, using a measure of computer self-efficacy. Results showed the majority of the responders rated their self-efficacy as good, with strong, positive correlations between these ratings and past experience with computers, hours per week of computer use, and number of software programs used. A significant difference between males and females in computer self-efficacy was found in favor of males.

In-Service Instruction

Interest in studying music technology with in-service teachers is emerging as a common topic. Reese Repp, Meltzer, & Burrack (2002) described the development of a multimedia website for online professional development for music teachers. The site was designed with content that stressed technology awareness, knowledge, and attitudes. It

was focused on providing teachers with help on using technology in positive ways. The site also contained many downloadable resources for teaching. The researchers divided a group of in-service teachers into three groups: a group that used the site as part of a summer course, a group that used the site apart from a course and a group that did not use the site. Data on effectiveness included pre- and post-test knowledge and attitude surveys. Logs of time spent were also included. Eight subjects were also interviewed separately. Data showed that the teachers did not use the site as much as was hoped and this made analysis of its impact difficult. Results for knowledge and attitude scores were mixed. The researchers concluded that face-to-face, personal interactions and structured schedules for learning may still be a better system, at least for this sample of teachers.

Bauer, McAllister & Reese (2003) studied the effectiveness of music technology summer workshops (intensive, one-week course) held at 19 locations with in-service educators (n=203) across varied levels of instruction and specialty. Research questions centered on whether such a workshop changed teachers' knowledge, degree of comfort, and frequency of use in terms of music technology for music learning. Questionnaires designed as pre- and post-test and follow-up instruments were created. The follow-up assessment showed continued and sustained gains in knowledge, degree of comfort and frequency of use, when compared to initial levels before the workshops; however, it was also noted that some falloff occurred when comparing scores on the follow-up to the post-test questionnaire data.

Byne & MacDonald (2002) conducted focus group studies of in-service teachers using technology in the music curriculum in Scotland. Teachers endorsed the use of music technology in instruction but worried about the level of support for such work by the local school officials. The two focus groups' main concerns centered on two broad themes: what and how music was taught. Issues described in the research included concerns for increased access, core skills, gender demarcation, parental support, and administrative issues.

Instruction of Music Technology

A new category of research to emerge was the study of music technology classes themselves. Walls (2000) published a compendium of ideas for integrating technology

into college music teacher preparation programs. The article included a number of examples of how to do this, taken from documented successes at various campuses. Hagen (2001) reported on a study of self-assessment and preferences of college students in a beginning technology class. Results showed that positive changes in attitude toward technology. There were no clear preferences for working on projects singularly or in groups, however females with less experienced preferred group work. Digital document transfer was preferred over printed hard copies and students enjoyed step-by-step directions versus on-line help or class notes.

Conclusion

Reviews of research and music technology growth in the period from1990-2000 demonstrated significant growth in the power and availability of hardware and software for music teaching and learning, but in-service teachers lagged behind in their application of these resources. There seems to be no major evidence that this has changed dramatically in the recent five years of research. There is some evidence that students come to college better prepared to use computers, but not necessarily for music software. We still lack real compelling evidence about how committed music teachers are in the integration of technology into music instruction. What is also lacking is extensive dialog about the conceptual bases for including music technology, with few major efforts to develop a philosophy of technology use.

The study of more exploratory, multimedia, and creative-based software has increased in the last five years; however, our ability to evaluate the effectiveness of the newer titles remains a major challenge. A real positive development has been the greater number of qualitative study have resulted in better understanding of the subtleties of learning, but much further evidence across many research methodologies is necessary. New interest in studying technology's role in in-service for teachers and undergraduate education is noteworthy. Additional attention in the last five years to studies that address distance learning and to the use of the Internet are noteworthy and will likely continue.

Most significant is that music technology research in the last five years continues at a pace faster pace then ever before. Substantial studies have been reported in many of the categories and research interest is growing as evidenced by work in professional

associations world-wide. We desperately need more substantial studies on teaching strategies that use technology, issues of gender and technology, equity in accessibility to the best resources, and the real effect of technology's use on long-term learning in music for professional musicians and the educated public as a whole.

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