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Key research in music technology and music teaching and learning

ABSTRACT

Research on the use of technology in music teaching and learning continues to grow in both quality and quantity. This article summarizes some of the important work since 2000, placing an emphasis on studies completed in the last few years. Both conceptual and philosophical publications are included as well as qualitative and quantitative work on technology in service to composition, listening and performance. One major conclusion is that we 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.

KEYWORDS

music technology
history
research
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The modern-day use of technology in music instruction and learning is a complicated confluence of music technology development in its own right, the varieties of music evident in our pluralistic societies, and an emerging pedagogy that favours individual expression, constructionist learning and creative thinking, while respecting the need for conceptual learning (Webster 2011).

Music, and its development as either a more formal art or as part of a practical cultural experience, has been influenced historically by technology of all sorts. This ranges from the design of instruments and the attendant issues of physics of sound (Miranda and Wanderley 2006) to the most recent ways

that music is consumed and distributed across the world with the assistance of online technologies (Ruthmann 2007).

On the hardware side, digital devices such as personal computers, tablets, phones and personal music players all support music sound files. The development of hard disk storage, laser disc technology, sampled sound as hardware resources has had a major effect on how music teachers do their jobs. In 2007, laptops were the most popular type of computer purchased and personal digital players like Apple's iPod, were among the most popular digital devices purchased by today's youth. Today, the tablet computer is rising quickly in popularity. According to one recent market source (Sarno 2011) manufacturers are expected to sell over 50 million tablet computers this year, with the number rising to 100 million in 2012. Laptops continue to be large sellers, but the tablet is expected to overtake the sales of laptops in coming years. Steve Jobs, Apple's visionary leader whose life ended recently much too early, famously claimed that this is the era of 'post-PC'. The implications for what this means for schools is clear. At this moment, we see schools in the United States beginning to invest in tablets largely because of cost savings, ease of student and teacher use and the variety of low-cost or free applications that are designed to run on such devices. This trend will surely continue in coming years. For software, we note several commercial titles for the support of music production (digital audio editing, traditional notation and graphics-based composition programs, loop-based composition and arranging, CD/DVD creation, music video/podcast presentations) and new work for music teaching and learning (intelligent accompaniment, simulators for composition and improvisation and titles designed to teach music concepts in a game-like or guided instruction setting) (Williams and Webster 2008).

Complicating the background further is the moral imperative felt by many teachers to use the technology more democratically to represent a wider array of sonic landscapes other than the traditional 'western canon'. The cultural use of music technology by wider populations of music makers in many countries of the world present interesting and important challenges for the pedagogy of music technology and its use by all students in schools. It is no longer possible to discuss music technology in instruction and learning without careful consideration of social context. Still, further discussion in the literature of music teaching and learning centres on the use of technology as a way to encourage explorative learning in creative music tasks that help the learner understand music less as a teacher-dominated 'do as I do' environment but more as a guided, construction of learning. Because the technology can be used as powerful tools for student-generated products, music teachers often see an interesting synthesis of technology tools with the adoption of new models of music learning. Recent development of interactive Internet resources, especially the sharing seen in social networking communities, adds still more flavour to this interesting topic. All of these trends are seen in the literature reviewed here. Burnard puts it well in the following:

> We know that technology is deeply embedded in the contemporary lexicon of young people's musical lives. The internet is their new playground and creates different social rooms for them. Its profound effect is conveyed in what sociologist Margaret Meade calls 'reverse heritage' – children encounter and familiarize themselves with innovations before their parents, and indeed teachers, do – a reversal of the usual hierarchical roles of parent and child and child and teacher.
>
> (2007a: 201)

This article builds on the reviews already published (Webster 2002, 2007). These reviews covered the majority of work from 1990 to 2005; I have canvassed the published literature since 2005 and include those studies that I think provide useful additions. The first section describes work of a more general nature and then I proceed to more focused studies on technology and music performance, improvisation and composition.

CONCEPTUAL AND PHILOSOPHICAL WRITINGS

Beckstead (2001), in an article on transformation of music education by technology, suggested that technology plays not only an efficient 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 online 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. Buehrer creates an excellent conceptual base for how technology plays a role in the recasting of traditional music theory pedagogy.

More recently, Crow (2006) writes persuasively for music technology as critically important for the encouragement of creative thinking in music. Writing from the British perspective and citing the early work of Schafer and Paynter, Crow reminds us of the power of recent advances in music technology.

> Powerful computers and fast Internet connections have become affordable and widely available. Technology's ability to manipulate audio has meant that many people, who up until now did not perceive themselves to be musicians, can handle, creative and communicate music using their computers. They employ inexpensive music software and hardware, which does not require 'traditional' musical skills or conceptual understanding.
>
> (2006: 123)

Crow also notes that such modern music technology may not prepare music students best for traditional theory and notation, performance and ensemble skills, or the music of western canon. He suggests that perhaps we need many music curricula: 'If music education of a generalist nature is to survive and flourish as a valid and worthwhile pursuit for pupils, then teachers will need to recognize pupils' creative outcomes in a variety of genres, and learn to foster, develop and assess those outcomes' (Crow 2006: 128).

Burnard (2007b) took a more philosophical position in arguing for a similar connection between creativeness and technology by consideration

of sociocultural theory, including post-Vygotskian Activity Theory. She built her case on the basis of several framing points including: (1) creativity and technology in terms of issues of *who, what, where, when, how* and *why*, (2) educational environments that conform to the learner, (3) Activity Theory as a basis for studying adaptive learning environments and (4) researching pedagogic change in music education. To this last point, Burnard contents that we should consider: 'Consulting pupils (i.e. giving learners a critical and democratic or genuine say) about the acquisition of technologies and opportunities to create their own learning technologies' (2007b: 48).

DISTANCE LEARNING, SOCIAL MEDIA/WEB 2.0 AND ONLINE COMMUNITIES OF LEARNING

For an overview of distance learning, readers might enjoy the summary chapter by Rees (2002). In addition, a meta-analysis of the effectiveness of distance learning in the general literature (Bernard et al. 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 online mentoring of music composition into course for music teachers by asking seventeen 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 e-mails 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.

Distribution of audio over the Internet for music instruction within restricted domains such as college campuses is now commonplace. 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's (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 capabilities. Systematic research on the effectiveness of these video conferencing experiments await completion.

Several studies have been published recently regarding the impact of the so-called 'Web 2.0' phenomenon – social media and its attendant notion of sharing content. Also related to this are examples of more 'informal' learning facilitated by the Internet via distance learning. Salavuo (2008) pointed to the problems of traditional learning management systems like *Blackboard* and similar systems developed for high school (e.g. Edline) that establish a teacher as largely the main designer of content. Rather, he points to the rise in social sharing sites as more powerful tools for learning. The author makes the case for the power of online communities that share content in shaping music education and lists many examples of how this is currently taking place. In the same year, Draper (2008) contributed a similar perspective by reporting an action research study with college students in Australia that claimed to support the use of Web 2.0 methodologies in a traditional conservatory setting. Although reported in the context of higher education, the implications for high school students are easily imagined.

Online communities of practice are emerging in recent years and may effect music education outside of formal school. For example, Waldron and Veblen (2008) document music learning in an Irish traditional virtual music community called IrTrad. The authors note that the online community helps spread the knowledge and experience of this tradition outside of traditional geographic boundaries. IrTrad began in part as a *listserv* but now uses many other forms of media such as YouTube and wiki sites to expand its content. Waldron (2009) extended this line of thought in an article that explored online communities of learning for music. I include this work because it may seem to be a threat to music teaching in the schools to some, but a real powerful tool for expanding instruction more formally to others.

TECHNOLOGY AND GENDER

Issues of gender and technology have occupied some researchers attention in recent years. There is a common belief that technology is a more masculine enterprise and that girls are less interested and less effective in the use of technology. Cooper (2007) used some qualitative and quantitative evidence to suggest that boys when composing with technology showed greater interest but that girls did equally impressive work in composition tasks. There appeared to be a preference amongst boys to work in single-sex groups but this was not always the case with girls. Armstrong (2008) offered a critical perspective on this subject, indicating that much of the perceived difference between genders is culturally determined. Abramo (2011) in a recent study of gender differences within popular music production groups of different genders found evidence for different styles of operation. Boys and girls rehearsed and composed music differently, with boys combining musical gestures and non-verbal communication, and girls separating talk and music production demonstrating more consultation. Abramo concludes:

> But just as there is a danger of putting students' processes into a priori categories, there is a danger of reducing gender in popular music practices to a simple 'boys do this and girls do that' dichotomy. A social constructionist framework of gender would suggest that these practices are not essentialist and are not necessarily or completely outcomes of one's gender or sex.
>
> (2011: 38)

ATTITUDE, SELF-EFFICACY AND SELF-CONCEPT

Matters of student and teacher attitude towards the use of technology in teaching are investigated as secondary concerns in many of the research studies reviewed here; however, several studies published 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 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 behaviour, 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 seventeen-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 towards 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 towards web-enhanced learning in a music education methods class. General attitudes towards this instruction was positive, but did vary somewhat based on whether the student had a home computer and the nature of their past experience with web-based learning.

Glenn and 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 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 favour of males.

STATUS STUDIES

Finally, I will note some status studies that might bear on the role of technology in schools. Music teachers seem to use technology more for administrative tasks as opposed to music curriculum uses (Taylor and 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 programmes in the southeastern United States. Of the responding institutions (n = 69) in states such as Florida, Georgia, Tennessee and six others, 39 per cent state that they had one to three technology courses for music education students and 64 per cent reported having at least one lab for music education technology. All responding institutions, except for one, indicated that knowledge of music technology was vital.

Meltzer (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. About 311 freshmen completed a survey (83% return rate) that sought to determine student experiences of, skills with and attitudes towards 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.

A study concerning the quality of music technology integration in the schools was reported from the United Kingdom (Mills and 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 behaviours 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.

Internet as a major way to consume music (Field 2001). 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.

Lastly, Abril and Gault (2008) demonstrated that principals of secondary school programmes would like to see more technology course offerings made available. Principals survey seemed to lack specific knowledge of such courses.

MUSIC LISTENING/AURAL SKILLS, PERFORMANCE AND COMPOSITION

This section includes summaries of empirical work, both qualitative and quantitative, in music teaching and learning since 2000 that addresses music technology directly. A study on preschool children's interaction with music technology was reported by Addessi and Pachet (2005). This study is one of the first to be published that deals with 3–5-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.

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.

A new kind of category of study is emerging of late that takes advantage of new instrument creation and music performance. For example, Savage and Butcher (2007) and Savage (2009) published work on engaging primary-aged and high school students in instrument design. Citing the development of popular instrument environments like *Wii Music* and *Guitar Hero* and their use in informal settings such as the household, the authors document experiments with the construction of custom instruments using the Playstation 2 and a personal computer. Case study methods were used to study how the students used these custom instruments. This work is similar to projects inspired by the MIT Media Lab in Boston with Tom Machover (http://opera.media.mit.edu/ToySymphony/musictoysmain.html); there, researchers have created toy instruments that can be played with ensembles, giving young students control over music expression in exciting new ways.

In addition to this, the development of 'smart' cell phone and laptop/tablet ensembles is beginning to be documented in the literature. Dammers (2010) provided one of the first such studies in music education with middle school children. Results indicated that compositions constructed within a band ensemble over a fourteen-week period showed the possibility of this approach to enhancing music learning.

The literature on music composition continues to profit from researchers using music technology to great advantage to allow students to think compositionally. In fact, of all the musical experiences, composition appears to be the most effected by the rise of technology use in terms of fundamental change in the way both researchers and practitioners study and teach music. Savage concluded his action research study with 11–16-year-old children composing with technology with this:

> In concluding this discussion on compositional processes with ICT it is important to remember the changing nature of evaluation and revision whilst working with technologies. An essential part of this process is the possibility for pupils to stand back from the activity of producing music (through playing instruments, singing or designing and engineering sound at the computer) and reflecting on what they are producing. The process of recording one's musical output is educative for any musician, whether performer or composer, but the opportunity to work interactively with technologies that accurately represent recorded sounds as compositional material demanded particular aesthetic qualities and judgments from pupils.
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> (2005: 178)

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 and Seddon 2001; Seddon and 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 and Folkestad (2005) reported on a two-year empirical study of nine 8-year-old Swedish children composing music with a synthesizer and computer software. As with Seddon and O'Neill, 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.
>
> (Seddon and O'Neill 2003: 35)

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 behaviour 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.

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 that served, in part, as bases for interviews with the researcher. A CD was made of the final compositions and notated scores were 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 and Kwami (2002) summarized the results of a set of focused interviews with students and teachers in eight schools following questionnaires on this topic from eighteen 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 trade-offs 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' (Pitts and Kwami 2002: 70).

Savage and Challis (2001) published a report that documented the use of short sound recordings and digital audio, multi-track 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.

Other important studies on the use of technology for composition in both US schools and those of the United Kingdom include Gall and Breeze (2005), Bolton (2008), Mellor (2008), Ward (2009), Hewitt (2009) and Breeze (2009). Using both qualitative and quantitative techniques, these recent studies continue to demonstrate the important role that technology plays in the music experience of composition in the schools.

CONCLUSION

Reviews of research and music technology growth in the period from 1990 to 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 worldwide. We 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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