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Chapter 14: Acquiring skills in music technology

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Abstract

This chapter explores how individuals acquire music technology skills in various settings. We consider this acquisition with reference to the psychological theories of behaviourism, constructivism and metacognition/metalearning. We also discuss what it means to learn, be creative and pursue a musical career within a fast-moving, technology-driven world. What do professional musicians, sound engineers and educators regard as key skills and competencies in music technology, how have priorities changed over time and what attributes are considered as essential for the future? We illustrate our key findings using a wide range of examples drawn from varied cultures, musical and educational settings.

Chapter summary

- Music technology skills are evolving to reflect technological, economic and cultural change.
- Defining specific skills in music technology is challenging, although some categories of skill endure longer than others.
- Skill acquisition in music technology is most effective within contextual and holistic learning environments.
- Skills in 'perimusical' technologies have attained great importance for musicians of all kinds in recent years.
- Essential skills for future music technologists may often not be 'technological' in the the traditional sense.

Keywords: technology, skill, learning outcome, competency, metacognition, metalearning, contextualised learning, entrepreneurism

Introduction

In English speaking countries, the term 'skill' is associated with professional employment (Canning, 2015), the implication being that one must acquire prerequisite skills through educational or praxial activity before successful entry to a particular occupation (Ericsson, 2006). In recent decades, the traditional definition of a skill as an acquired, specialized cognitive or psycho-motor behaviour has evolved in response to new patterns of employment and industrial change (Gregory, 2004). It is now common for educators and employers to differentiate between these more traditionally-conceived skills (now often termed 'hard skills') and those related to various interpersonal and intrapersonal qualities (often termed 'soft skills') (Melser, 2018). The likelihood of individuals needing to move between different forms of employment over a working lifetime has resulted in the concept of 'transferable' or 'generic' skills. In contrast to 'specific' skills, these are regarded as having relevance to multiple occupational domains (Balcar et al, 2011).

Reflecting these vocational origins, music technology skills were traditionally defined in relation to the requirements of the professional recording studio. The influence of behaviourist models of learning led to attempts to define and codify specific, hard skills deemed necessary for success in this environment. Yet, a review of some thirty years of literature confirms two important developments. The first relates to the significance of constructivist models of learning, introduced to help music technologists acquire a range of soft and transferable skills to complement and enrich specific, hard skills. The second, more recent development relates to the growing influence of metacognitive learning. This is leading to entirely new ways of conceiving music technology skills, a development that partly reflects the importance of lifelong learning at a time of both *sunrise industries* (e.g., online and virtual music platforms) and *sunset industries* (e.g., analog equipment and physical media). Fundamentally, however, it also reflects more fluid, individualised notions of what it means to make music—and to make a living from music—in the twenty-first century.

In this chapter, we explore each of these conceptualizations of music technology 'skill' through the lens of relevant psychological theory. Whilst we do note a definite chronological precedence, we wish to avoid the suggestion that any one of these conceptualizations is inherently 'better' than the other two. All three coexist and have enduring value for music and music technology educators. Indeed, they resonate with the first three 'big topics' outlined in the forward of the 2017 *Oxford Handbook of Technology and Music Education* which continue to frame the "social and technological landscape" of contemporary music education (Webster and Williams, 2017, p.xiii). Specifically, "(1) the tradeoffs between constructionist and direct instruction, (2) the encouragement of creative and critical thinking, (3) the role of interdisciplinary engagement, both within music and between music and other fields" (ibid.).

Music technology skills as 'learning outcomes': behaviourist perspectives

Learning outcomes are "statements of what a successful learner is expected to be able to do at the end of the process of a learning experience" (Gogus, 2012, p. 2534). The increasing popularity of learning outcomes in education has been cited as evidence of a renewed influence of behaviourism (Murtonen et al., 2017). Whilst they are most frequently encountered within higher education, there are also examples of outcomes-based models of music education in other phases, such as Education Scotland's (2018) school music curriculum and the European Commission's *Learning Outcomes in Music Teacher Training* (Institut für Musikpädagogik Wien, 2009). Underlying motivations for these initiatives include concerns over educational access and cultural entitlement, assessment and quality assurance, increasing globalization and marketization of education and a belief that learners need more systematic preparation for professional life: the so-called 'employability agenda'.

A number of researchers have employed empirical methods to construct lists of pertinent music technology skills. There are typically expressed as learning outcomes since they describe the behaviors that should be observable once the skills have been mastered successfully. We review three examples of these studies, relating to the perceived technological requirements of undergraduate musicians, students of music education and intending audio engineers respectively. Webster and WIlliams (2018) conducted a six-year study intended to identify core technology competencies for undergraduate music students. The authors use 'competence' to describe the "critical understandings that underpin the application of the music technology skills" (2018, p. 22). An initial longlist of 51 competencies was constructed in areas of acoustics, file and disk formats, digital audio/recording and editing, notation, teaching, collaboration, distance learning, multimedia, digital citizenship and historical trends. 772 teachers of music in higher education, mainly from the United States, rated this list to produce a final set of eleven competencies for which there was consistent support (Table 1a). Dorfman (2015) sought to identify technology "skills and conceptual understandings" (p. 1) regarded as especially useful for music teachers to possess, and which might therefore be prioritized within programs of initial teacher education. 237 pre- and in-service music teachers were asked to rate 48 such skills, adapted from Webster and Williams' interim findings, resulting in nine particularly highly-rated items (Table 1b). Tough's (2010) study attempted to predict the competencies likely to be required by audio engineering students graduating in 2019. Like others, Tough employed the term 'competence' as a composite construct to describe "the possession of particular knowledge, attitudes, or skills that enable an audio graduate to serve at an acceptable level of performance" (2010, p. 153). Three rounds of panel surveys were held with music and audio industry professionals. An initial longlist of 255 competencies in the areas of general audio, the Musical Instrument Digital Interface (MIDI), digital audio, business skills, music, electronics, communications and leadership was generated by these professionals, reduced to 160 through subsequent rounds, then rated. Tough's top twelve items are shown in Table 1c.

Table 1: highly rated music technology skills for undergraduate musicians (a) (Webster & Williams, 2018), students of music education (b) (Dorfman, 2015) and intending audio engineers (c) (Tough, 2010)

a)	(b)	(c)
1. Enter and edit music using notation software. 2. Understand the basics of digital audio and how to edit digital audio files. 3. Record and mix a performance with digital audio software. 4. Demonstrate an understanding of copyright and fair use. 5. Create a music presentation with production software and appropriate hardware. 6. Create a streaming audio file (sharing recordings). 7. Demonstrate an understanding of MIDI and its applications including performing with electronic, digital and non-traditional instruments. 8. Demonstrate setting up a computer music workstation/problem solve technical issues. 9. Demonstrate an understanding of acoustics and audiology. 10.Create and edit a simple music video. 11.Use and manage a variety of social music sharing tools. (Webster & Williams, 2018, p. 25)	1. Use notation software to create worksheets and other teaching materials for music. 2. Edit a score with a music notation program, including transposing parts, copying and pasting notation, and saving scores in different formats. 3. Use a digital audio program to record a music performance and save the file for listening. 4. Create a musical score with a notation program that includes expressions, articulations, and appropriate music notation conventions. 5. Burn an audio or data CD with a computer. 6. Use a computer or other device to control a video projector or 'SmartBoard' projection system. 7. Use presentation software to support a presentation about music that uses text, animation, digital video, and graphics. 8. Understand the capabilities of different levels of music notation software, including options for online notation. 9. Use hardware and software to assist in improving music performance skills (Dorfman, 2015: 10).	1. Demonstrate the ability to work hard and complete projects. 2. Recognize the need for personal responsibility. 3. Demonstrate the ability to be an effective listener towards co-workers and clients. 4. Demonstrate the ability to communicate clearly and tactfully with clients and co-workers. 5. Develop the ability to be professional around clients. 6. Demonstrate a BASIC knowledge of effects including EQ, reverbs, delays, gates, limiters. 7. Demonstrate dependability. 8. Demonstrate the ability to pay attention to detail. 9. Show a strong passion for what they do. 10. Analyze BASIC audio signal flow in the recording studio. 11. Work effectively on a team. 12. Put into practice the ability to handle criticism. (Tough, 2010: 161)

Lists of music technology skills such as these raise interesting questions both about their derivation and application. With regard to the former, methodological divergence may help explain why the top-rated skills/competencies are quite different in the three studies. Specifically, whilst the first two studies prioritized mainly harder skills, participants in the third appear to have been more concerned with generic, soft(er) skills. This may relate to rater background, not least because participants in the first two studies were drawn from the education sector, where the influence of behaviourist psychology has placed great emphasis on observable, quantifiable assessment outcomes (Murtonen et al., 2017). Secondly, in the case of Webster and Williams (2018), the generation of the initial 51 competencies was undertaken by the researchers in consultation with fellow experienced teaching colleagues, then subjected to moderation during a series of presentations at professional educational conferences. Collectively, these raters possessed diverse music specialisms and worked in different kinds of higher education institutions. Perhaps reflecting this diversity, the final shortlist prioritizes 'building block' skills with wide applicability to a range of musical activities.

Subsequently, Webster and William's longlist was adapted by Dorfman (2015), who also recruited participants from within the music teaching community. However, in this case, they were drawn from two specific populations: intending and serving school music teachers. Perhaps as a consequence, Dorfman's shortlist appears to reinforce traditional identities of the musically-literate performing musician and classroom practitioner. Of the top nine skills, four concern notation software. Whilst Dorfman acknowledges that these might have been used by respondents to facilitate creative work, he nonetheless notes a tension with the growing emphasis on 'sound-before-symbol' composition activities in music education. Two of the nine skills relate to making and displaying presentations using slide software and projector hardware, both rooted in the realities of daily life in the classroom rather than saying anything specific about being a music teacher. A further two skills suggest an extension of the traditional performer identity rather than helping to define a digitally-creative music educator. The skill 'burn an audio or data CD' is interesting in that it is the highest-rated hard skill included in either Webster and Williams' or Dorfman's lists. Yet whilst it may have reflected the state of computer hardware when the research was conducted, it also illustrates the time-bound limitation of this kind of skill specification, given computers are now routinely manufactured without optical media drives and rely instead on cloud-based or solid-state storage. CD burning is thus an example of a 'transient skill' (Gower 2015, p. 30), just as the manufacture of optical media may be an example of a 'sunset' industry.

As Dorfman (2015) acknowledges, it is understandable that raters might privilege skills which they already possess, not least because they remain less appreciative of the usefulness of skills not possessed. Given their undeniable relevance to modern classroom practice (Thompson, 2014), it is somewhat surprising that abilities to 'edit a sound file by cutting, copying and pasting portions' and 'add simple effects such as loudness control and fade in and out' were not rated higher, for instance. In contrast, the inclusion of so many generic, soft skills within Tough's (2010) shortlist—also those featuring prominently in a further survey of US audio professionals conducted by Bielmeier (2014)—suggests a pragmatic acceptance that this industry is too diverse and fast-moving to bother listing transient hard skills. Instead, high-rated items like 'recognizing the need for personal responsibility' (Tough, 2010, p.161) and 'life-long learning and continuing personal development' (Bielmeier, 2014, p.3) imply a general expectation that music technologists will actively acquire new hard skills as novel technologies bring them to the fore. In both surveys, those few hard skills which *are* rated highly relate to basic audio signal flow, microphone and recording techniques, and effects processing. These arguably constitute 'enduring skills' within music technology (Gower, 2015, p. 30) since they are not only more durable but also transfer readily between, for instance, analog and digital domains and live, studio or laptop-based workspaces.

Notwithstanding the implications of methodological and rater variance, lists of discrete skills have an important place in education, particularly as a means of setting out curricular coverage. Music technology workflows typically combine multiple pieces of hardware and software, each requiring specific techniques to operate effectively (Dorfman, 2015). Some studies suggest that learners value opportunities to gain confidence with each stage in the process without having to simultaneously apply their new skills for creative ends (Gall and Breeze, 2007; Hebst, 2016). Yet, as Toulson (2011) notes, whilst these skills *can* be taught in isolation, this is not the same as learning to apply them in dynamic studio environments. To an extent, the usefulness of context-free skills acquisition depends on the stage of education reached. Once sufficiently inducted into a working studio environment, for instance, it may again be appropriate for learners to undertake more focused engagement with tools and processes in order to plug any remaining gaps in the systematic acquisition of skills (Gower, 2015).

Defining music technology skills as learning outcomes risks becoming particularly contentious if these outcomes come to *drive* rather than *inform* curricula, pedagogy and assessment. This is a well-known risk of relying too strongly on traditional behaviourist learning theory (Murtonen et al., 2017) and, at its worst, can risk education becoming reduced to a series of atomised, context-free 'skill checklists', devoid of appropriate musical, professional or social contexts (O'Neill & Senyshyn, 2011). Drawing on Bloom's taxonomy (Murtonen et al., 2017), Toulson (2011) argues that context-free music technology learning activities cannot go beyond knowledge transfer, the lowest level in Bloom's system. Accessing the higher levels requires situating skills in context, where "practitioners can develop their own ideas, put them into practice and evaluate and evolve to perfection" (2011, online). With the rapid growth in formal programs of music technology over the past thirty years, the extent and quality of this contextualization may have varied. Bielmeier (2014) documents concerns expressed by US audio engineers that many fresh graduates entering the field in the 1990s and 2000s lacked communication skills and a sense of the “social dynamics of the studio” (p. 2). They were also perceived to have “poor attitudes and misguided expectations” (Bielmeier, 2014, p. 2) about their industry, to lack responsibility and the ability to respond to feedback or take criticism. In contrast, for industry professionals, “the ability to work well under stress, be an astute observer, be easy to work with, and have a sense of humour was paramount for aspiring engineers” (Bielmeier, 2014, p. 1). Surveys of UK-based audio professionals over the same period suggest some educational programmes may have a had similar focus on “tools and technology rather than the social, aesthetic and human skills” (Parker and Davis, 2013, p1).

None of this is to suggest Webster and Williams, Dorfman or Tough would wish their lists to influence education in such teleological directions. In fact, Webster and Williams express their own concerns about the implementation of technology within some American higher education music programs, similarly noting that this is “often deterministic with tech driving application and content” (2018, p. 22). Furthermore, of the top twenty skills in Tough’s (2010) study, eighteen related to communications, leadership and personal skills. Skills in business were regarded as no less essential as those in basic electronics, troubleshooting and MIDI. Moreover, these researchers are clear that their respective lists should be taken as the bases for diverse, experiential learning activities. Like many audio professionals (Bielmeier, 2014; Parker and Davis, 2013), they identify a need for music technology skill acquisition to take place within integrated and interdisciplinary settings which place equal and holistic emphasis on the development of a wide range of contextual soft skills.

Developing music technology ‘skills’ through holistic learning experiences: constructivist perspectives

Our review of the international literature from a thirty-year period confirms a strong trend for music technology education to have re-focused on skill acquisition within contextualized learning experiences. Many claims about the benefits of these kinds of learning have been made and we next explore these through the lens of constructivist psychology. According to Taetle and Cutietta, constructivist theories of learning music:

> acknowledge the interconnections between the learner and his or her environment as crucial for understanding the process of learning itself. Therefore, the study of learning is approached from a more holistic perspective. Interactive theories acknowledge the multifaceted, multidimensional complexity that ensues when an individual encounters and responds to musical stimuli not only in the context of the group(s) of which he or she is a part but also in the context that is created by the mental and physical environments surrounding the interactions (2002, p. 284).

Constructivist learning experiences emphasize interaction with oneself, one’s peers and the surrounding environment and it has been argued that music technology is an inherently interdisciplinary field, best taught and learned within integrated settings. Walzer (2017) suggests students of advertising, photography and business as potential learning partners for music technologists but sees particular value in collaborations with those studying so-called ‘STEM’ subjects, that is, those within science, technology, engineering and mathematics (thereby strengthening the case of those wishing to add arts to this quadrumvirate so that it becomes ‘STEAM’ (e.g. Welch, 2012)). Walzer looks towards sunrise industries to provide vocational models for all such collaborations, particularly those such as “gaming, social networking, new media, digital humanities that require coding, programming [and] teamwork” (2017, p. 15).

Music technologists require strong communication and teamwork skills. Drawing on the ‘community of practice’ concept (Lave & Wenger, 1991), Walzer (2017, p.147) argues for the importance of “honing one’s craft, while simultaneously participating with a group of like-minded practitioners”. When collaborators have competing skills or propose alternative approaches, being able to articulate, justify and debate one’s position also become vital (Gower, 2015; Hebst, 2016). No less important is the need to develop strong client liaison skills (Bielmeier, 2014; Tough, 2010; Walzer, 2017). As Reddington (2016) notes, music technologists must learn to be effective ‘suppliers’ to third-party ‘clients’, balancing personal creativity with commercial imperatives. The ability to work independently and to remain self-aware have also been highlighted (Rosas et al., 2016). Particularly relevant are self-motivation, self-reliance and personal accountability for meeting project deadlines. Moreover, whilst personal skills in analysis, logical reasoning and decision making may seem mundane, educators cannot afford to take them for granted; not all learners will master them without active support (Lefford & Berg, 2015; Ronan & O’Shea, 2018; Walzer, 2017). Some learning activities are rich enough to support development in several of these areas simultaneously. For instance, Cheng (2019) found that participation in laptop-based performance ensembles aided skills in leadership, motivating oneself and others, decision making, interpersonal communication, oral communication, and problem solving.

Much collaboration is no longer face-to-face. Musicians of all kinds must now be skilled in networking, gathering material and distributing their outputs online (Reddington, 2016). Distance learning programs have an important role in this regard. Rosas and colleagues (2016) found that students using a virtual learning environment to collaborate on a composition project were still able to develop proactive social skills. These could then feed back into improved technical skills, since exchanging musical material required learners to handle diverse file formats. The European Union’s Open Sounds project has put such a vision into practice, developing an online composition environment specifically intended to promote collaboration amongst diverse groups of learners on both creative ideas and project management (Himonides, 2013).

The need to integrate skill development in *music technology* and in *music* is important. The sophistication of DAW software is now such that effective development can occur in both domains simultaneously and interchangeably. As a common ‘entry point’, DAWs offer learners multiple aural and visual methods of revising and revisiting creative work over time, potentially helping to develop ideation, editing and appraisal skills with as much relevance to traditional musical composition as to audio editing (Gall & Breeze, 2007; Schroth et al., 2009). However, school-age learners' ability to make the most of music technology in areas such as composition, listening, theory and notation, vocal and instrumental technique has been linked to more advanced pre-existing musical and computing experience (Hernández-Bravo, et al., 2016; Merrick, 2002). In professional life, traditional musical skills in aural awareness, staff notation, music theory and orchestration remain in demand for music technologists, for instance to support live recording sessions (Reddington, 2016).

A challenge of constructivist learning is that it is not always possible to assess the extent to which targeted, individual skills have been fostered by an activity. Instead, the activity's final 'product' may need to stand as a holistic indicator of overall success. This is a central tenet of construct<u>ionism</u>, a variant which highlights the potential for learning through creating physical artefacts, effectively 'thinking' through one's fingers and via the objects that one creates (Harel & Papert, 1991). Thaler and Zorn (2010) report on a year-long interdisciplinary, collaborative initiative for Austrian high-school students. Utilising both off-the-shelf music technologies and various makerspace materials, learners overcame design challenges to realise various end products. For instance, a Nintendo Wii-controller was modified via PureData programming to become an 'air piano', whilst sound and video-editing projects involved effects processing and the use of sample libraries. These served as implicit illustrations of the technological skills acquired. For Thaler and Zorn, such products are "externalized thoughts. They either work properly or they do not. Thereby, they demonstrate the existence and quality of thought and action" (2010, p. 449).

The developmental benefits of collaborative, interdisciplinary music technology activities are maximized when there is sufficient openness on the part of learners. This can be manifested as openness to different forms of creativity (Gower, 2015), flexible working contexts (Klein & Lewandowski-Cox, 2019), unfamiliar sonic resources and musical languages (Rosas et al., 2016), and to the critical evaluation of one's own work (Bielmeier, 2014; Walzer, 2017). Educators should actively challenge, encourage and support this openness, whilst simultaneously developing technical proficiencies (Gower, 2015). Cognitive apprenticeship can be an effective means of introducing students to "new modes of culturally relevant learning through watching, interacting, teaching, guiding, and listening—just as the apprenticeship trade has done for years" (Walzer, 2017, p. 148). Undertaken in 'situated learning' environments mimicking real-world settings, cognitive apprenticeship blends formal knowledge transfer learning with less formal approaches such as mentoring, peer learning and, crucially, a safe space in which to make mistakes.

As the nod to the 'apprenticeship trade' suggests, the classroom is only one—and not necessarily the best—of many environments in which learning can occur. In the past, the well-trodden path from studio 'tea boy'[1] to assistant engineer was a common means of inducting newcomers into the 'rich culture of music recording and mixing expertise, built up over decades' (Tingen, 2015, p. 52). Yet, with progress in equipment reliability and miniaturization, the rise of laptop studios and software virtualization, and the associated decline of mid-range recording studios, these informal apprenticeships have all but vanished (Bielmeier, 2014; Huws, 2017; Reddington, 2016). There have been growing calls for the formal education programmes that have filled this void to adopt 'apprentice-like' learning conditions, even if apprenticeships themselves are now unviable (Bielmeier, 2014, Davis & Parker, 2013). Methods including fixed-term internships and pairing learners with professional mentors or musicians have found favour (Nordström & Nordström, 2013; Tough, 2010). The considerable potential of extra-curricular 'service learning', work-based or practice-based learning, community outreach and capstone projects has also been demonstrated (Gower, 2015; Walzer, 2017; Webster & Williams, 2018). Even when faced with challenges of cost, resourcing and staff-to-student ratios, the argument goes that educators must still strive to recreate their benefits when possible (Bielmeier, 2014; Lefford & Berg, 2015).

Similar kinds of cognitive apprenticeship strategies have proved effective in informal, alternative and community education settings. Here, the absence of 'teacher' and 'student' labels can promote strong collaboration and skill sharing between facilitators and participants, some of whom might be considered disenfranchised or disadvantaged in terms of traditional music education (Baker & Cohen, 2008; Brader & Lurke, 2013; Hesnan & Dolan, 2017). These settings also offer the promise of legitimizing certain forms of music technology skill acquisition not traditionally found in formal education, for example, learning through social media or via respected members of the local community. As such, they support the acquisition of skills in music technology and many associated soft skills in networking and employability. Moreover, as implied by the earlier use of the gendered term 'tea boy', the demise of some aspects of studio culture might be less lamented than others. These apprenticeships did not always provide an equally conducive atmosphere for aspiring female music technologists (Wolfe, 2019). In a bid to confront gendered stereotypes within the discipline, particular efforts have been made to support girls' and women's skill development through community workshops and school outreach programs in various countries (Baker & Cohen, 2008; Hayes, 2017). Key research findings here include the importance of female role models and facilitators, and opportunities for structured collaboration (so that no one group dominates), peer sharing and encouragement. Single-sex environments may have a place during initial stages, or in order to support specific skill development for a limited period. However, they may also be counterproductive, reducing the pool of learners with whom skills can be learned and shared, and implying that certain

[1] The gendered connotations of this term are considered below.

skills sit more comfortably with certain social groups (Grugulis & Vincent, 2009) and that ‘special’ forms of support are therefore required.

The Internet offers significant potential to replicate aspects of the traditional studio apprentice experience. As Huws (2017) notes, tutorial videos and live-streamed studio sessions enable learners to observe technical practices, and perhaps also professional and interpersonal interactions to an extent. In developing countries with fewer formal education options but rapidly improving mobile telecoms networks, there are particular opportunities in this regard (Gleeson, 2013). However, with no ability to clarify or question what is shown, well-developed critical thinking skills are needed to evaluate contradictory or dubious advice. Specially-authored multi-camera angled and/or multi-audio tracked video footage offers one (albeit resource-intensive) solution (Toulson, 2011). Yet there is still a need for learners to apply this observational learning practically and remain reflective about how far these experiences can prepare them for unfamiliar working environments (Huws, 2017). In time, the growing potential of virtual reality may lead to still more immersive, sensorially richer observations.

Finally in this section, the constructivist emphasis on learning-in-context necessitates acknowledgement that the acquisition of music technology skills occurs alongside—and interacts with—the acquisition of technological skills in other-than-musical areas. The latter might usefully be described as ‘perimusical’, since many of these skills have become conceptually integral to musical engagement of all kinds, even though they are not directly involved in production of music itself (Torres Mulas, 2000). There are links here, firstly, with Savage and Challis’ (2001) observation that some technologies become sufficiently musically aligned to be rendered invisible in the learning process and, secondly, with Purves’s notion of ‘intermediate’ music technologies as “small, low-cost, and increasingly pervasive technological tools” (2018, p. 143). Pertinent examples of contemporary perimusical technologies include social media, now a means of not only promoting one’s profile, performances and recordings (Reddington, 2016) but also of coordinating rehearsals and undertaking administration (Webster & Williams, 2018). When combined with streaming and downloading, social media also become important means for keeping abreast of musical trends, troubleshooting and of developing one’s critical voice through discussion (Hyang, Jeong and Seog, 2014; Wise, 2010). In fact, as Court-Jackson’s (2011) study of older people’s limited confidence with online music demonstrates, the importance of perimusical skills involving the Internet is now such that an individual’s failure to master them may severely curtail their continuing engagement with music.

Given the entrepreneurial nature of many contemporary musicians’ work (see below), presentation software used to engage audiences in impactful ways is another important form of perimusical technology (Dorfman, 2015). Even musicians who eschew technology as a pedagogical or creative tool are still likely to make use of office-style software within administration tasks (Webster & Williams, 2018). Notation skills can be fruitfully combined with those in online searching, as in Wise's (2010) fieldwork example of students collating printed chord sheets and tablature from the Internet into personal songbooks. For those active in music-based research there are yet further technology skills to acquire. Bauer's (2016) survey suggests that expertise in handling e-journals, bibliographic databases and management, portable audio/video recorders, data analysis and online conferencing software are particularly crucial in this regard.

Developing music technology 'skills' in a world of metacognition and metalearning

Constructivist learning emphasizes interactions with others and one's environment. In the case of music technology education, these interactions are often with others sharing similar career aspirations and are enacted within environments modelled on traditional music industry workplaces. There is, then, a strong sense in which learners are being prepared to join the ranks of a 'credentialed' workforce; they being exposed to—and evaluated against—professional standards and expectations, even if this is implicit. A preoccupation with the employability agenda means that this is to be expected within higher education. However, a vocational subtext often pervades other settings, for instance community programs touting 'music industry links' (Gardiner & Peggie, 2003) or school websites boasting of 'industry standard' studio equipment (Purves, 2018). Ultimately, these all rely to greater or lesser extent on the availability of a relatively stable, economically-viable music 'industry'. To be 'industry-ready implies that we have some understanding of the nature of the industry' (Davis and Parker, 2013, p. 5).

Yet, as noted, technological and socio-economic change has now eroded many of the music industry's traditional structures. We have also witnessed the reduced influence of multinational record labels and the overwhelming rise of the Internet as a distributing and marketing medium (Reddington, 2016). Taken together with broader economic and cultural shifts, this suggests that fundamental aspects of musicianship are now subject to change. In the United States, these factors motivated the College Music Society's decision in 2013 to convene a task force to "consider what it means to be an educated musician in the twenty-first century" (Sarath et al., 2017 p. 49). The result was a curricular reconceptualization based on the three pillars of creativity, diversity and integration. Musicians of the future, concluded the task force, will need stronger creative skills in areas of improvising, composing and performing than they will in areas relating to the interpretation of existing works. Webster and Williams (2018) have in turn argued cogently for the central role that music technology will continue to take in this reconceptualization.

The taskforce highlighted the ongoing evolution away from traditional performing careers towards an "intentional integration of audience engagement, self-management, artistry and education work" (Sarath et al., 2017, p. 129.). A focus on integration also underpins other contemporary re-appraisals of skill acquisition. 'T-Skilled' or 'T-shaped' professionals are those who possess highly specialist expertise in one area but who have also acquired so-called ‘threshold’ skills necessary to engage effectively in related fields (Baguyos & Shafer, 2018; Gower, 2015). Music technology education adhering to this concept typically augments creative musical skills with those in computer programming and networking, graphics, broadcast and interactive media, web technologies, and intellectual property management. Reinforced through the promotion of soft skills in project management, agile methods and the kinds of communication and personal skills outlined in previous sections, this breadth is intended to enable learners to flexibly reposition their careers in allied fields such as computer games development. There is resonance too with ‘fusion skills’ (Bamford, 2019). Highly transferable, adaptable and blendable within multiple disciplines, these embrace many of the personal, organizational, collaborative and communication skills already outlined. In the ‘fusion’ manifestation, however, they are regarded not as supplementary to a core discipline but of equal or greater importance since the very survival of this discipline may come to depend on them. For instance, musicians now face competition from ‘content professionals’, adept at working creatively across a broader range of media (Gower, 2015). Whilst the latter might not always have the depth of expertise and subject knowledge of the former, content professionals may nonetheless have the fusion skills needed to thrive in a highly-fluid, online environment. Just as professional photographers needed to redefine themselves in the wake of the introduction of mass-market, low-cost cameras in the 1950s, music technologists must now adapt to a world in which high quality music production tools are accessible to anyone who has a computer and an Internet connection (Tough, 2010).

As Bamford (2019) notes, technology is not only the key agent of change but also an essential means by which fusion skills can be harnessed for creative empowerment. As noted, the Internet has disrupted the physical distribution of music, depleting musicians' traditional forms of revenue. Yet for adaptable musicians who can embrace the technology, Bamford points to the growing potential of Blockchain (the distributed, digital ledger system) as means of reconnecting with paying audiences in more equitable, profitable ways. Examples such as this give hope that we might be entering an era when music technology skills are no longer dictated by the perceived requirements of a homogeneous ‘music industry’ but are instead shaped by individuals’ creative aspirations within increasingly diverse social, cultural and economic contexts.

Musicians, notes Hallam, have always required effective metacognitive strategies to help them “identify their own strengths and weaknesses, assess task requirements and develop strategies to overcome particular task difficulties and optimize performance” (2001, p. 37). However, the rapid evolution of both the music industry and of the musician archetype (see Chapter 23) may now have reached a stage where more is required. Musicians of all kinds will increasingly need to remain in a permanent state of ‘horizon scanning’, ready to reconfigure their skills and undertake associated cost-benefit-risk analyses. Originally defined by Biggs as “being aware of and taking control of one’s own learning” (1985, p. 204), metalearning has been re-appraised by Bialik and Fadel (2015) who use the term to describe a model of metacognition augmented through the inclusion of Dweck's (2006) growth mindset concept. An education emphasizing metalearning, they argue, "sets students up to succeed in lifelong, self-directed learning, in the productive careers they may choose, and in continuing to grow throughout their lives, as the world continues to shift" (p. 6).

Having sketched out a radically altered musical terrain, we must next ask what constitutes metacognitive 'readiness' for today's music technologists? One term that repeatedly jumps from the literature is 'entrepreneurism'. Reddington (2016) points out that musical innovation and entrepreneurial activity typically both flourish at the margins of cultural and commercial activity. Innovation and entrepreneurism both require dedication to the cause in the face of limited resources and the absence of a foolproof plan for success. They are underpinned by an ability to spot gaps in the market, develop niche specialisms and, fundamentally, adopt a "say yes to everything mentality" (Reddington, 2016, p. 5). Yet, the concept of entrepreneurism is not limited to the commercial sector and also relates to innovative leadership in teaching and learning, social enterprise or community activities (Baker & Cohen 2008; Dorfman, 2015; Webster & Williams, 2018). Commonalities include the need to 'pitch' new strategies to others, capitalize on emerging opportunities and function effectively as agents of change. Whilst music was always a freelancer's industry (Cilleti, 2005), the rate of change means that is increasingly less viable to carve out a stable career identity as, say, a 'freelance engineer' or 'freelance producer'. Many educators recognize the need to actively incubate entrepreneurial skills within music programs (Crawford, 2014; Gower, 2015; Huws, 2017; Miksza & Hime, 2015), for instance through the incorporation of formal 'design thinking' methodologies (Ronan & O'Shea, 2018).

One particularly fraught implication of adopting an entrepreneurial approach is accepting the inherent risk of failure if things do not work out as planned (Shepherd et al., 2016). In fact, it is highly likely that failures *will* occur during music technologists' learning and professional journeys (Thorley, 2018). Learning from failure can be highly emotive and difficult but also offers enormous potential to drive the acquisition of new knowledge and skills (Reddington, 2016). However, whilst failure might sometimes be regarded as a 'badge of honour' for entrepreneurs who ultimately achieve success (Shepherd et al., 2016), it can have different connotations in formal education. In situations where music learners put in a great deal of effort and still find themselves falling short, the experience can be demotivating and frustrating, compounding culturally-embedded self-perceptions of musical ability as fixed and unchanging (Legette, 2012; McPherson & Hallam, 2009). Thus, despite the educative potential of supported failure being well recognized professionally, music technology teachers can often be understandably reticent to embrace its potential in their classrooms (Thorley, 2018). In the neoliberal climate of results league tables, student satisfaction polls, and concerns over student recruitment and retention, the idea of intentionally exposing learners to risk seems perverse, even if it is evident to all that risks nonetheless loom large beyond graduation.

Risk aversion may actually go some way to explain the enduring appeal of programmes of music technology education, despite the existence of low-cost technologies and free learning materials online. Scaffolded learning activities supervised by experienced tutors provide opportunities to make mistakes in relatively safe and stable environments (Davis & Parker, 2013; Walzer, 2017). Thorley (2018) researched the learning potential of failure in supported yet authentic ways. Undergraduate students were given pre-recorded multitrack audio files to remix as desired, with no tutor guidance issued. The mixes were evaluated by an independent music professional, who identified elements of 'success' and 'failure' within each. No assessment criteria were used - an anathema in the behaviourist, outcomes-driven world in which many contemporary educators must operate. Yet despite inherent uncertainty, the task proved successful in providing students with opportunities to develop not only technical expertise but also thinking and creativity skills. Specifically, they developed abilities to work with third-party materials, apply stylistic references, pursue personal visions, manage production processes and undertake self-evaluation. Importantly, students did not appear thrown by the lack of criteria, instead valuing the authentic nature of the feedback received. Such a finding lends weight to Legette's (2012) suggestion that music teachers should actively assist in the constructive analysis of learners' failures, making explicit links with potential future successes. Put another way, failure must be 'domesticated' within music technology education (Ronan & O'Shea, 2018).

One means of achieving this domestication is to emphasize the importance of risk and change management practices (Della Ventura, 2014; Dumbreck et al., 2003). A pertinent example relates to the need of music technologists to manage inevitable trade-offs between mastering current technologies and learning skills in novel areas (White, 2018). Engaging meaningfully with unfamiliar technologies typically requires significant investments of time and money and these must be carefully offset against existing creative and/or employment opportunities. In postmodern creative contexts, this requires more than simply remaining abreast of leading-edge developments. We are currently witnessing the re-emergence of analog synthesizers and recording systems, vinyl records and even compact cassettes. This retro revivalism (Brøvig-Hanssen & Danielsen, 2016) is a reminder that the direction of technological travel is not one way. Those engaging with such trends are apt to discover that they must suddenly be skilled in techniques long-since regarded as obsolete. The contemporary need to master music for the limited frequency response of a mobile phone speaker presents similar paradoxical challenges for music technologists whose training and experience has privileged 'high fidelity' playback. Thus, developing a 'radar' for promising creative trends and scenes, helping limit investment in passing musical fads and highlighting the need to migrate to new tools or re-appraise old ones is vital (Reddington, 2016). Music technologists must remain reflexive, aware of how their own discipline will impact on musical performance practice (Himonides, 2019), ready to move between amateur, semi-professional and professional working contexts and cross from one hardware or software platform to another with ease. With the need to scan, evaluate and risk-assess now so apparent, some have proposed that critical thinking, reflection, networking, evidence gathering, synthesis, analysis and working with a sense of purpose are not merely *key* skills for music technologists. They have essentially attained the status of *technological* skills in their own right (Huws, 2017; Hyang et al., 2014; Thorley, 2018; Walzer, 2017).

As will be clear by now, preparing music technologists for this new world is not easy, yet there are further challenges. Some of the ‘skills’ listed above, such as risk tolerance and resilience, are more accurately described in psychological terms as personal attributes or traits. Although debate continues, many regard attributes linked to occupational preparedness as relatively stable in practical terms; whilst change is possible, this requires significant time and cost (Heckman and Kautz, 2012; Smith & Arnkelsson, 2000). Learners require sufficiently powerful educative experiences that can bring about metacognitive awareness of the potential for change (De Corte, 1990).

We may also ask whether the active preparation of music technology students to survive in precarious economic climates inadvertently condones unfair, divisive and unsustainable working practices. After all, one economist’s dream of an ‘agile’, ‘flexible’ creative industry workforce is another’s neoliberal nightmare of an unstable, unpredictable ‘gig’ economy. Whilst music might indeed be the original gig economy, the socio-economic shifts outlined above have emphasized some of the worst aspects of this epithet (Haynes & Marshall, 2018). Given that critical thinking skills are now strongly emphasized, should learners be encouraged to use these to critique the economic systems they will soon be expected to join? Recent growth in music teaching cooperatives in the UK demonstrates that other, viable educational models exist (Musicians’ Union, 2015). Educational and community programs offered by artist-run collectives can evolve alternative forms of pedagogy emphasizing self-directed learning and personal experimentation (Joss, 2010; Prestianni, 2003). Developing creative skills in situations where teachers view themselves as co-creators and learners are free to “make and remake their own and each other’s work… offers potential push back to… the individualization, competition and commodification upon which neoliberal education policy relies” (Wright, 2019, p. 223). At the very least, there are strong arguments for the contemporary music technology skill set to embrace resilience not only in the *professional* sense but also in the *psychological* sense. As Gross and Musgrave (2017, p.29) observe, “there is no ‘Health and Safety Manual’ for the music industries”. They call for educators to embed mental health provision, helping ensure that musicians are prepared emotionally for an uncertain future.

Collectively, these factors present those with the responsibility of educating today’s music technologists with great challenges, since they must bring about deep personal development, including within complex and emotive psychological areas and in the face of limited time and resources. Delivering on this responsibility has exercised many and there is evidence from some countries of an increasing emphasis on metacognitive skills including adaptive, divergent and computational thinking, and new media literacy. Some have begun to promote concepts such as social intelligence, and cognitive load management skills (Gower, 2015; Klein & Lewandowski-Cox, 2019). In the case of one Australian undergraduate music technology programme, the curriculum has been refocused away from “20th century recording studio practice” to “interactive creative music making” using mobile, online and desktop technologies (Klein & Lewandowski-Cox, 2019, p. 3). To support this change, teaching has shifted to embrace cultural diversity, virtual and interdisciplinary collaboration, problem-based and ‘flipped’ learning scenarios which promote not only technology and engineering skills but also those in performance, composition and improvisation. Taking forward the principles of T-shaped skill acquisition, students continue to specialize but also gain experience translating musical skills into a range of allied disciplines.

Conclusion

By way of a conclusion, we join with Kaiser (2018) in asking what it might mean to be a *virtuoso* music technologist in the contemporary era. The notion of musical virtuosity is historically linked to the demonstration of prodigious physical skill and instrumental technique, an association reaching its zenith with the Romantic era performances of Liszt and Paganini. Yet the continuing, rapid evolution of all forms of music technology forces us to consider this association afresh, particularly with regard to the many genres—such as electronic or sound based musics—which have emerged since these earlier times, and which owe no legacy to these kinds of historical musical markers. Kaiser’s ethnographic study of contemporary musicians working in the field of electro-acoustic improvisation identified at least three re-conceptualizations of virtuosity. The first of these would best be described as the ‘anti-virtuosic view’, in that some of Kaiser’s interviewees felt completely alienated by the traditional meaning of the term, unable to disassociate it with displays of motoric skill or the idea that performers should be evaluated against others’ standards. Instead, they wished their work to be considered as the expression of individual creative identity, perhaps no surprise in a genre “dominated by idiosyncratic performers, instruments, and improvisers” (Kaiser, 2018, p.93). Yet if, as the evidence suggests, the influence of the traditional ‘music industry’ on education continues to wane, then we may hope that one outcome will be greater autonomy in terms of both the tools and skills employed by music technologists of all kinds. Theirs is, after all, both an *objective* and a *subjective* discipline (Toulson, 2011).

Some of Kaiser’s other interviewees saw value in redefining the virtuoso concept to embrace physical skills more aligned to modern music technology interfaces, such as fader control. As one put it, “if you want to perform in a convincing way you have to react and this implies that you know your tools” (quoted Kaiser, 2018, p. 93). We see parallels here with the theme running throughout this chapter of the importance of regular, committed and critical development of skills - of practice (as a verb, in the sense of the old joke ‘How do you get to Carnegie Hall?’).

Others move the virtuoso concept away from physical skills entirely to a conceptual definition more closely aligned with ‘artistry’, thereby embracing notions of virtuosic listening, knowing, decision-making, managing, exploring, cross-domain working, imagining, remembering and metaphor using. It is no coincidence that this is one of the strongest themes to come from our chapter: many of the most highly-prized skills for modern music technologists are not *technological* (in the traditional sense) at all. We are, as Clements (2018) notes, entering the ‘postdigital era’, characterized by a ‘the growing hybridity of digital and traditional music making, and the influence of digital technology on human artistic practice’ (p.48). We find Landy’s (2007) use of the term ‘faktura’, as developed from the thinking of French electro-acoustic composer Marc Battier, helpful here as it reminds us of the intrinsic connection between sets of tools and their transformation or adaptation in creative use. Those able to exploit this connection to the full may become the true music technology virtuosi of the future. As we have suggested, many aspects of this dawning era are as yet uncertain or unfixed and so music technologists have an opportunity to re-imagine their tools and their discipline’s defining skills. One of us (Himonides, 2017) has already set out some of the implications of recent, linked developments in ‘big data’, social media technologies and evidence-based practice on the education and development of future music teachers. But we hope that this chapter makes it clear that similar challenges await all musicians, who must be similarly “ready to polish old tools, forge new ones, creatively abuse existing tools, methods, and processes” (Himonides, 2017, p. 629). It will be only through the agile acquisition, application and cross-fertilization of the widest range of ‘hard’, ‘soft’, and metacognitive skills that music technologists will meet the creative, educational and professional challenges of the future.

Issues for further research

- Country-specific studies (e.g. Gower (2015) and Klein & Lewandowski-Cox (2019)) help us understand music technology skill acquisition within policy, economic and cultural contexts. Further, comprehensive studies would be welcome for other territories, although international reviews and benchmarking are also important.
- It is possible that ‘big data’, data mining and social media-based research methods may enable more dynamic curations of pertinent music technology skills that reflect musical, economic and technological trends over time.

- Both ethnographic and quantitative, system-level approaches are valuable in this field. We need to understand the impact of change on patterns of musical activity as a whole but also implications for individual creative artists.

- Further work should help educators evaluate the creative and occupational efficacy of placing increased emphasis on metacognitive skills relating to music technology.

Implications for education and music in the community

- Skill acquisition in music technology should no longer be dictated by the perceived needs of a homogeneous 'music industry'. Industry professionals still have a very important role to play in helping educators design music technology programs, but their insights will be just as useful in regards to the acquisition of metacognitive, interpersonal and intrapersonal skills as acquiring skills in particular technologies and tools.

- Learning music technology skills of all kinds relies on enriching, integrated and diverse learning environments. These environments may be fruitfully nurtured in both traditional classrooms and community settings. The Internet plays an increasingly important role in supplementing and complementing face-to-face settings.

- Augmenting classroom-based music technology education with apprentice-*like* learning scenarios offers powerful learning opportunities.

Suggestions for further reading

- Toulson (2011) compares music technology skill acquisition in simpler, exercise-based contexts and richer, holistic learning experiences.
- Webster and Williams (2018) explore several decades of music technology evolution and the implications for the skills required by musicians, teachers and learners.
- Clements (2018) offers a highly thought-provoking piece on the increasingly blurred boundaries between human creativity and digital technology.
- Klein and Lewandowski-Cox (2019) provide an illuminating summary of the practical challenges and opportunities faced by music technology educators in the transition to more metacognitive teaching and learning approaches.

Reflective questions

- What music technology skills do you rely on in your day-to-day musical practices? Think about the full range of skills covered in this chapter. How many of these are 'hard', 'specific' skills and how many are 'soft' (e.g., metacognitive, intra-or inter-personal)? How has your music technology skillset changed over time?

- What are the most powerful learning experiences you have encountered during your lifelong music technology ‘journey’? Where did these take place? Who and what was involved?
- How do you learn best when engaging with music technology? Do you read the manual? Look for videos online? Follow structured tutorials in magazines? Just ‘mess around’ or ‘try to break it’?

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