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ITP5035

Towards a Framework of Requirements for Music Learning Support Tools

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ABSTRACT

While many areas of the music industry make extensive use of information technology, the impact of interactive educational tools on instrumental music learning has been limited to date. This paper considers the skills required by musicians, creative and physical, and proposes a framework for tool development based on approaches to supporting creativity, music-learning and human-computer interaction.

1 INTRODUCTION

Some areas of the music industry make extensive use of information technology (IT), but the impact of computers on music learning itself remains limited. That is, while a pianist or keyboardist may use extremely advanced technology to produce and capture sounds, the way in which she learns her skill is unlikely to be fundamentally different to the way her teacher learned to play.

As interactive educational tools begin to emerge to support instrumental music learning, we feel there is a danger that they will be based on narrowly defined theories of creativity and learning. This is understandable – the technical skills required to develop music-learning support tools are often considerable, and as these tools are in their early stages of development it is to be expected that developers create tools based on available technologies and leave details of their use to musicians and music teachers. However, if computer-based support tools are to make a genuine contribution to music-learning, a more comprehensive approach is required.

It is the aim of this paper to present a framework upon which to base the development of these tools that takes into account research into creativity, music learning and human-computer interaction (HCI). It is expected that the framework will evolve in response to experiences developing these tools as part of a collaborative research project between the Creativity and Cognition Studios at the University of Technology Sydney and the Sydney Conservatorium of Music. This paper thus represents an initial attempt at devising a comprehensive framework for music-learning tool development.

2 MUSICAL SKILLS

Musicians require skills in two key areas. Firstly, they must develop the necessary physical skill to express musical ideas on their instrument, and secondly they require creative skills in order that their musical ideas will be interesting to others. For convenience and clarity, we consider here these two areas separately, although they are in reality inextricably intertwined.

2.1 Creativity

Creativity is a fundamental part of music performance. Due to the inherent limitations of music notation, even when musicians are performing music composed by someone else there is a significantly creative component in the discovery, interpretation and realisation of the composer's intentions. However, the term 'creativity' remains somewhat nebulous.

There is general agreement that creative ideas are novel, but importantly are also 'fit-for-purpose'. That is, an idea that is completely new, but does not fit the constraints of the problem at hand is merely bizarre (Sternberg and Lubart 1995). In musical terms, the intended purpose may be defined to a greater or lesser degree and thus 'problem finding' can form a major part of the creative act. Thus it is likely that the musician must first decide the nature and goals of the artwork and then actually create it, quite likely refining the goals and creative processes as they proceed (Edmonds and Candy 2000).

Csikzentmihalyi (1996) puts the view that we are born with an innate curiosity and tendency towards creativity, but that this tendency to explore and discover new ideas may be easily discouraged. Just as bad teachers may (unwittingly?) discourage creativity in their students (Sternberg and Lubart 1995), it could be argued that badly designed support tools may do more harm than good. Tools that limit the user's options and/or impose rigidly defined work processes are likely to have a detrimental effect on the creativity they are attempting to support.

Motivation is a key factor in creativity and this aspect has been considered extensively by Amabile (1996), who argues that the *type* of motivation is important and that people who find a subject area intrinsically interesting are more likely to produce creative results than those who are motivated by external rewards. It seems that extrinsic motivation, in which a reward is offered for creative work, actually has a detrimental effect on creativity, as it encourages a more conservative approach to both problem finding and problem solving. Those hoping to support music learning with computer-based tools should therefore be wary of incorporating simplistic reward structures into their programs. They may in effect actually subtly discourage the behaviour they wish to foster.

2.1.1 Supporting Creativity

Given the somewhat nebulous nature of creativity, is it possible to devise a set of guidelines for how best to support it? Nickerson (1999) makes several (non-IT specific) recommendations, based on the creativity research literature, for those seeking to support and enhance creativity. The 12 recommendations are as follows:

- Establish purpose and intention
- Build basic skills
- Encourage acquisition of domain-specific knowledge
- Stimulate and reward curiosity and exploration
- Build motivation (especially internal motivation)
- Encourage confidence and a willingness to take risks
- Focus on mastery and self-competition
- Promote supportable beliefs about creativity
- Provide opportunities for choice and discovery
- Develop self-management (metacognitive) skills
- Teach techniques and strategies for facilitating creative performance
- Provide balance

Table 1 Application of Nickerson's recommendations to music-learning support tools

Establish purpose and intention	Make the goal of building creativity explicit. (Include the word 'creativity' in the software title for example.)
Build basic skills	Support and encourage development of instrumental technique to facilitate creativity. ie. Help improve technical proficiency.
Encourage acquisition of domain-specific knowledge	Provide facilities for listening to 'expert' performances.
Stimulate and reward curiosity and exploration	Allow customisation and extension. Eg. Allow performances to be visualised in ways that encourage new approaches.
Build motivation (especially internal motivation)	Be wary of 'psuedo-objective' evaluations of sound and other qualitative aspects. Encourage focus on musical end results and avoid triggering 'paralysis by analysis'. Include support for 'communities of practice'.
Encourage confidence and a willingness to take risks	Avoid overly-judgemental feedback. Allow/encourage experimentation in a socially supportive environment.
Focus on mastery and self-competition	Allow retrieval of previous performances to demonstrate progress.
Promote supportable beliefs about creativity	Encourage realistic expectations of the tool. Don't gloss over the fact that musical creativity requires commitment.
Provide opportunities for choice and discovery	Provide facilities for customisation and discovery of personal preferences. Avoid inflexible assumptions about what constitutes 'great music' or 'great sound'.
Develop self-management (metacognitive) skills	Provide facilities for keeping practice diaries or similar tools.
Teach techniques and strategies for facilitating creative performance	Provide support for considering problems (musical and physical) in a different light. Encourage playfulness and considered work at the edges or extremes of technique.
Provide balance	Provide structure without stifling innovation and spontaneity.

If we are to apply these general recommendations to the development of music-learning support tools then we need to make them more specific. In Table 1 we show how these ideas might be applied to the music-learning domain.

These attempts at targeting Nickerson's recommendations for music-learning support tools provide a good starting point for moving towards more detailed guidelines for tool development, but in many ways they are still too general. For example, in order to 'build basic skills' we know that it is necessary to help improve technical proficiency, but how specifically should this be approached? Are there pitfalls that should be avoided? To answer these questions, it is necessary to decide on some guiding principles for physical skill development.

2.2 Physical Skills

Any attempt to translate Nickerson's recommendations into more concrete requirements requires consideration of a theory of music learning. Of course it is possible to build tools without explicitly choosing a methodology upon which to base an approach, but we would argue that tools designed in this way are likely to have embedded within their design an implicit theory of music-learning which may be overly simplistic or naïve. To mitigate this tendency and to provide a kind of 'reality check' for developers, we now propose an approach to music-learning to incorporate into our framework. It is hoped that this will help ensure that tools are not made available simply because they are technically feasible. Rather, they must be aligned with a sound pedagogical approach.

The psychology and physiology of motor-skill learning is indeed complex (eg. Altenmüller and Gruhn 2002), but a practical approach to music teaching and learning that incorporates many of the theories and research in this area was devised and applied by Arnold Jacobs, former tubist with the Chicago Symphony Orchestra and renowned pedagogue (Stewart 1987, Frederiksen 1996). This approach leans heavily towards the music learning approaches articulated by Kodaly and Suzuki and, more recently, by Kohut (1985).

Jacobs' approach emphasises the importance of leaving the physical aspects of manipulating musical instruments to the subconscious. The argument is that if the delicate and complicated muscle manoeuvres required to produce a sound on an instrument are left to the subconscious, the conscious mind can be left free to concentrate on the creative musical and emotional aspects of performance.

An example given by Jacobs to illustrate the conscious/subconscious division is the mental processes involved in reaching for a glass of water:

'Here, you are not concerned with the musculature of the biceps and triceps in the arm. You are not concerned with compensating for the gravitational pull of the earth while lifting the glass. These are complexities that the brain manages. A simple command is sent to the brain to get a drink of water and the brain controls the complexities of an action. It would be a waste of time to analyse the complexities that the brain automatically performs in the subconscious.' (Frederiksen 1996, p.108)

Jacobs argued that the best way to improve instrumental motor skills was to change the demand made by the conscious mind. As the detailed muscle movements are beyond the control of the conscious mind anyway, the musician should focus on high-level concepts such as the desired sound. Such an approach also helps avoid 'paralysis by analysis' which can occur when a musician attempts to consciously control physical actions at a micro level. This is akin to trying to alter the way a ball is caught by consciously contracting certain muscles.

The implications of this approach are significant for those hoping to support music learning with technology. It suggests that tools designed to help musicians improve their technical skills should be designed in such a way that the user's focus is kept on the desired result – great sound and music – rather than the mechanisms required to achieve that result.

The fundamental problem is that no two people are physically identical, and there is more than one way to produce a good sound. Therefore, a tool which reports to the musician that they are moving their hand in a different way to their teacher is not necessarily providing useful, usable information. In fact it could well be argued that it is likely to reduce motivation and encourage an unnecessarily conservative approach.

3 HUMAN COMPUTER INTERACTION (HCI)

Recent work in the field of human-computer interaction (HCI) has turned towards improving the support of creative work with IT, or perhaps more accurately, to removing impediments to creativity unfortunately often embedded in software tools. Shneiderman (2000) has proposed the 'genex' framework – short for 'generator of excellence' – with the aim of making improvements to the design of web-based services and other software tools intended to facilitate creative work. Observations of support tools in use draw similar conclusions about requirements for creativity support (Greene 2002).

The framework suggests that creative work involves four phases (Shneiderman 2000):

Collect	Gather information relevant to the task at hand.
Relate	Consult with peers, experts.
Create	Explore possible solutions in an iterative fashion. Evaluate various possibilities.
Donate	Share results, display artwork, contribute to libraries.

It can be seen that genex is both a theory about the nature of creativity and a framework for improving current IT based support for creative acts. It leans heavily towards the systems view of Csikszentmihalyi (1999), that creative acts are fundamentally tied to the social system in which they take place. Thus, social events such as consulting with peers and sharing results are an integral part of the creative process.

Shneiderman suggests eight activities that take place within the four genex phases:

- Searching and browsing digital libraries
- Consulting with peers and mentors
- Visualizing data and processes
- Thinking by free associations
- Exploring solutions- what-if tools
- Composing artefacts and performances
- Reviewing and replaying session histories
- Disseminating results

Table 2 - Possible support for music learning activities

Activity	Support
Searching and browsing digital libraries	Allow musician to search for and listen to samples of outstanding musicians on their instrument
Consulting with peers and mentors	Allow posting of practice sessions and trial performances for feedback.
Visualizing data and processes	Provide graphical representation of aspects of a performance, such as sound quality, in order that the performer might perceive patterns in, or qualities of, their playing that had previously gone unnoticed. Some interesting work in this area has been conducted by Nishimoto and Oshima (2001).
Thinking by free associations	Provide a diverse range of performances and sounds, both in the performer's domain and outside it. For example, trumpeters are able to listen to saxophone performances; jazz musicians can access classical recordings, etc.
Exploring solutions- what-if tools	Allow musician to combine aspects of various recordings. Eg. Take a portion of one recording and overlay it with another to 'see what would happen'.
Composing artefacts and performances	Allow musicians to record practice performances and to compare with previous recordings of their own playing and others.
Reviewing and replaying session histories	Keep a history of all performances for the purposes of tracking improvements or noticing 'blind alleys'. Allow comments on past recordings to be stored.
Disseminating results	Provide facilities for sharing recordings and practice histories with others. Support for communities of practice.

The idea here is that an integrated application for supporting creative work will, at a minimum, provide tools for supporting the activities in this list. To illustrate the point, a comprehensive support tool for music learning then, might support these activities in the ways outlined in Table 2. It should be noted that some of these functions may be difficult to implement for various reasons - problems with copyright laws for example - but they are listed nonetheless to indicate the broad implications for tool design of the genex framework.

The genex approach helps by making the higher-level goals of Nickerson more computer-specific as well as emphasising the social aspects of creativity. It can be seen that many of the activities are really more concrete instances of Nickerson's broader recommendations. For example, Nickerson's recommendation to 'Encourage acquisition of domain-specific knowledge' maps directly to the genex activities 'Searching and browsing digital libraries' and 'Consulting with peers and mentors'.

4 TOWARDS A FRAMEWORK FOR DEVELOPING MUSIC-LEARNING SUPPORT TOOLS

Having presented the three cornerstones of our approach to music-learning support tools, we are now in a position to present them as a specific framework of guidelines and functional suggestions for those interested in developing computer-based music-learning support tools. We therefore present a summary of likely features of a comprehensive instrumental music-learning support tool that have been derived from the three approaches introduced in this paper. These features may of course be offered in separate modules, but are listed here together to give an indication of the integrated nature of the framework.

Features for building domain knowledge

- Provide facilities for listening to 'expert' performances.
- Allow musicians to record practice performances and to compare with previous recordings of their own playing and others.

Features for encouraging a creative approach

- Allow customisation and extension. Provide graphical representation of aspects of a performance, such as sound quality, in order that the performer might perceive patterns in, or qualities of, their playing that had previously gone unnoticed.
- Allow sharing of experiences with other users. Provide case-studies and background information on 'great performances'.
- Provide facilities for customisation and discovery of personal preferences.
- Provide facilities for keeping practice diaries or similar tools.
- Keep a history of all performances for the purposes of tracking improvements or noticing 'blind alleys'. Allow comments on past recordings to be stored.
- Provide support for considering problems (musical and physical) in a different light. Encourage playfulness and considered work at the edges or extremes of technique.
- Provide a diverse range of performances and sounds, both in the performer's domain and outside it.
- Allow musician to combine aspects of various recordings. Eg. Take a portion of one recording and overlay it with another to 'see what would happen'.

Features for sharing, collaboration and building motivation

- Allow posting of practice sessions and trial performances for feedback.
- Provide facilities for sharing recordings and practice histories with others. Support for communities of practice.
- Allow retrieval of previous performances to demonstrate progress.

Overarching goals

- Foster the desire to be creative. Make the goal of building creativity explicit.
- Support and encourage development of instrumental technique to facilitate creativity.
- Be wary of 'psuedo-objective' evaluations of sound and other qualitative aspects. Encourage focus on musical end results and avoid triggering 'paralysis by analysis'.
- Avoid overly-judgemental feedback. Allow/encourage experimentation in a socially supportive environment.
- Encourage realistic expectations of the tool. Don't gloss over the fact that musical creativity requires commitment.
- Provide structure without stifling innovation and spontaneity.

5 CONCLUSION

The three key approaches discussed here - Nickerson's twelve recommendations for creativity support, Jacobs' approach to the psychology of motor-skill learning and Shneiderman's *genex* approach to developing creativity support tools - form a powerful foundation upon which to build music learning support tools. Taken together, they may be considered a 'call to arms' for teachers and software developers to consider the pedagogical and psychological implications of the use of various computer-based tools carefully. Teachers may use the proposed framework to evaluate currently available tools and consider how they might best be incorporated into their teaching (if they are to be incorporated at all) and developers may use it as a basis for informing the design of future tools.

There is a considerable challenge before musicians, teachers and developers to devise and implement genuinely useful tools in this area. We have mapped out some areas for future work in this paper and it is hoped that the framework presented here will be refined and extended as such tools emerge. Further empirical research on the development and use of music-learning support tools is required.

While new technologies for capturing and displaying audio data will no doubt continue to emerge, it is hoped that a framework such as the one proposed here will facilitate the production of genuinely helpful tools. An unfortunate consequence of a technology-driven approach is likely be the emergence of tools that encourage an overly mechanistic approach to music learning. A theoretical framework that encourages developers to give greater thought to both the pedagogical implications of tool design and the way in which the interaction between user and machine is structured may go some way towards mitigating this tendency.

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