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Teaching Music Composition with Digital Tools: A Domain-Specific Perspective

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Abstract

This chapter explores the role of software used to teach composition in music education in two different musical domains, described as interval-based and sound-based, respectively. Affordances and constraints of digital composition tools, and how these relate to models of creative processes, are examined. Three questions frame the investigation: Which perspectives on creativity and learning frame music education in interval-based (pop) and sound-based (electroacoustic) music, respectively? What are the affordances and constraints of digital tools when teaching composition in the different musical domains? How may principles for supporting creativity and learning be applied in teaching and assessment in sound-based music education? To exemplify the latter, we draw on data collected from a Norwegian composition workshop in sound-based music.

Introduction

As the digital paradigm began to make itself felt in the arts during the early 1990s, digital tools were making their way into all aspects of creative music production, including composing, performance and recording. During this pioneering period of digital history, *computer music* emerged as a genre, although the term was soon rendered imprecise by the widespread use of computers in nearly all types of music productions. Today, electroacoustic or *sound-based* music (Landy, 2007) are more generally accepted terms describing genres of music in which sounds and their development alone create and maintain musical interest in a composition. An important stance in the domain of sound-based music was introduced by composer Edgard Varèse, who proposed that music rests on the deliberate organization of any sound (Varèse, 1966). However, composer John Cage contended that it is the act of listening that turns sounds into music, regardless of whether the sounds have been deliberately organized (Cage, 1939). Contemporary artist Bill Fontana embraced both perspectives in his view that "from a musical point of view, the world is musical at any given moment" (Rudi, 2005). Perhaps most essential to composing and appreciating sound-based music, then, are skills in deliberative listening, whereby musical narrative and meaning are constructed in both the abstract and the concrete. This type of deliberate listening also distinguishes sound-based music from interval-based music; through active engagement in both the contexts and micro-phenomena of sound there is the potential to change a listener's understanding of what constitutes music. How might creativity and learning in such a musical domain be conceived and studied?

A domain-specific view of creativity argues that to explain creative accomplishment in music "knowledge and skills rooted in the content and activities of a particular domain are necessary" (Kozbelt, 2017, p. 163). Accordingly, creativity specific to the domain of sound-based music, as with other forms of artistic expression, is defined by experts in the field (Kaufman & Beghetto, 2009; Sawyer, 2012). A working definition of sound-based music will thus include the ability to produce new and unique sound material; to understand and work with the referential and spectral properties of sound; to hear, identify and compare contexts and origins of different sounds; to produce new relations between types of sound material; and to use sound material in musical expressions as a compositional resource in unique ways (Emmerson, 1986).

A concentration on abstract movement of timbre in space is perhaps most crucial to distinguishing sound-based music from an historically trained attention to harmonic, rhythmic and melodic movement in interval-based music. As there are no formal compositional rules, conventions have emerged to define different types of sound-based music, e.g., *electroacoustic*, *noise music*, *glitch*, *turntablism* and other approaches to sound file playback (Cascone, 2000).

Although sound-based music historically dates back to the late 1940s, the development of digital tools and software introduced sound-based composition approaches and aesthetics into both professional and educational practices on a broader scale, putting new aspects of timbre and musical structures within reach of more composers, musicians, teachers and students. Digital composition tools also became widespread in interval-based music, which remains most prominent in music education curricula in schools and colleges (Dobson & Littleton, 2016; Vratulis & Morton, 2011). Today, the use of digital tools and apps is the international norm in music education (Wise et al., 2011), concentrated on composition in 'pop' music and the familiar cultural references and structures that characterize this type of interval-based music. The appeal of teaching composition in pop music may be explained in part by easy access to freely available sequencing software like *GarageBand*, *Soundation* and *Incredibox* and sound editing programs like *Audacity,* which allows the simple manipulation of sounds. In comparison, sound-based music is a small musical genre with little visibility in classroom contexts and fewer freely available and easy to use digital tools for teaching composition.

In this chapter we consider the relationship between features of digital composition tools, teaching approaches, and perspectives on creativity and learning in music education. We explore nuances and contrasts in these relationships by reviewing studies of digital composition tools in both interval-based popular music and sound-based music education, identifying key perspectives on creativity and learning in the respective domains. The aim of the chapter is not to compare or evaluate types of music, but to contribute to domain-specific perspectives on creativity and learning in technology-enhanced music education, with a particular focus on sound-based music. We draw on understandings of *musical creativity* as situated in specific practices, with values and features that differ accordingly, defined by Odena (2012) as "the development of a musical product that is novel for the individual and useful for the situated musical practice" (p. 203). Three questions are investigated: Which perspectives on creativity and learning frame music education in interval-based (pop) and sound-based music, respectively? What are the affordances and constraints of digital tools when teaching composition in the different musical domains? How may principles for supporting creativity and learning be applied in teaching and assessment in sound-based music education? To exemplify the latter, we draw on data collected from a Norwegian composition workshop in sound-based music. We draw on established use in the learning sciences (Gibson, 1977; Roth, Woszczyna, & Smith, 1996) of the concepts 'affordances' and 'constraints' to analyze the action possibilities of digital tools and software features in a non-deterministic approach.

Composition and digital tools in music education

In recent years, perspectives on creativity and learning in interval-based (pop) and sound-based music education have been respectively developed in what are mainly qualitative, smaller scale empirical studies. Creativity research on digital composition tools in schools, on the other hand, has overwhelmingly focused on the widespread use of notation and sequencer software (e.g., *GarageBand*, *Jam2jam, eJay)*, which entails organizing pre-made instrumental samples into sound file representations typical for genres of pop music. Empirical studies of sound processing software (e.g., *SoundHack, SoundEffects, Compose with Sound*, *DSP*[1]*, ProTools*) to compose and think in sound or sound-based music are less common. Across types of digital tools and music domains, areas of music education research that are relevant to our topic include studies of *implementation and use* (Brown, 2007b; Dobson & Littleton, 2016; Gall & Breeze, 2008; Hewitt, 2009; Savage, 2007; Vratulis & Morton, 2011), *learning and creative processes* (Dillon, 2004; Gall & Breeze, 2005; Hewitt, 2009; Nikolaidou, 2012; Rudi & Pierroux, 2010; Wolf, 2013;) and *teaching and assessment approaches* (Webster, 2007; Wise, Greenwood & Davis, 2011). Research on creativity in music performance and composition more generally are not discussed, as they fall outside the scope of this study.

Implementation and use

In a study of the use and implementation of information and communication technology (ICT) in music education in schools in the UK, Savage (2007) found that students experienced pride, enthusiasm, and increased motivation when they created music, and that they took responsibility for their own creative and learning processes. In the same study, in which eighteen schools participated, Savage also cautioned that schools may develop too much of a focus on the technology used in teaching, pointing out that practical and technical challenges might require too much concentration and possibly result in less interaction between students. Savage concluded that schools would benefit from a more open acceptance of the potential of technology in music instruction, and that it was easier for students to compose music using technology than without. Other studies in North America have similarly found that ICT increased engagement in music education, and that students were inclined to work harder in music technology classes than in other classes (Webster, 2007; Cooper, 2009). Such studies on

[1] DSP is a common abbreviation for 'Digital Signal Processing,' here referring to the name of a specific software developed for music education purposes.

implementation and use support a general consensus in the literature that digital tools add value to music education.

Learning and creative processes

In recent decades, studies of creativity and learning have been increasingly framed by constructivist (Way & Webb, 2007) and sociocultural perspectives (Sawyer, 2012), which emphasize the mediational role of contextual resources in processes of creativity and learning (Rudi & Pierroux, 2009). Situated contextual resources may include digital tools and representations but also interactions with teachers, peers, and the learning organization of group collaboration in classrooms. Applying a situated framework, Dillon's (2004) mixed methods study analyzed dialogue and collaboration among young people composing music using *eJay* in formal and informal learning settings. The focus of the study was to investigate how creative collaboration processes in composing interval-based music influenced students' meaning-making and fostered shared understanding. Dillon concluded that the software, participants' musical skills, and the learning organization mediated collaborative interactions that align with generally accepted definitions of creativity in music (Webster, 2001; Kozbelt, 2017), involving both divergent and convergent thinking that develop in stages over time, and resulting in a musical product that is new for the creator. Studies by Brown (2007a) and Gall & Breeze (2005) similarly found that software *Jam2jam* and *Ejay* supported younger students in collaborating, externalizing ideas, and stimulated action and reflection. Studies have also documented creative and learning processes in *sound-based* music education. In a study by Falthin (2014), two upper secondary students were first introduced to electroacoustic music and then presented with the highly structured task of synthesizing spectra and composing with the results. One of Falthin's findings, confirmed by other studies (Holland, 2015; Wolf, 2013), was that the students' concept development was as strongly linked to listening and music appreciation tasks as it was to composition tasks in sound-based music.

Teaching and assessment approaches

The link between concept development and music appreciation skills points to specific challenges in teaching composition in sound-based music, namely, that this is an unfamiliar domain that students may experience as 'alienating' (Higgins & Jennings, 2006; Wolf, 2013). Research on teaching sound-based music education has identified specific issues, including the need for listening curriculum that can develop students' conceptual and critical thinking (Wolf, 2013) and for teaching approaches that can support students working with longer phases of creative work in an abstract problem space. Approaches to facilitating creativity and learning with more open-ended composition tasks and tools are a further challenge for teachers in sound-based music education in that they are required to listen to the content of the sound development in students' works to understand the processes they have been working through. Therefore, in a large-scale study conducted in three UK middle schools, Wolf (2013) designed curriculum and teaching approaches that tested the development of students' *appreciation* of sound-based music according to principles of active, collaborative and self-regulated learning, respectively. The study found that structured listening training and teaching key concepts of electroacoustic music enhanced appreciation, broadened students' vocabulary for describing their listening experiences, and produced positive learning outcomes in inexperienced listeners' factual, conceptual and procedural knowledge. Advance preparation that included listening activities was also identified as necessary for achieving desired learning outcomes in a different study in Ireland involving a teacher and ten 16-year-olds in a school by Higgins & Jennings (2006). This research was designed with three variations of teacher guidance in *composition* classes, with the aim of understanding how pedagogical designs may develop and support students' higher-order critical thinking skills in relation to electroacoustic music. The students' works, teacher observations and student interviews were analyzed following each round of composition work, comparing processes of guided/unguided composing, collaboration, and learning using a digital audio editor tool (*Cool Edit Pro*). Effective teaching strategies for electroacoustic composition were identified as *preparatory work* (e.g., adequate technical skills, prior knowledge of sound materials and how they can be transformed, familiarity with musical context and composition elements like time, pitch, change, structure and balance); *being available but not intrusive*; and *focusing attention through appropriate questions* (Higgins & Jennings, 2006). We apply these findings to the description and analysis of a *DSP* workshop presented below.

In contrast, a consistent finding in studies of teaching composition using sequencer software like *GarageBand* is that the tool's structure and affordances can productively scaffold student work with minimal teacher assistance (Wise et al., 2011). Dillon found that the strong visual interface and immediacy of feedback in the *eJay* tool design allowed participants in both types of settings to "instinctively, with minimal effort, produce music collaboratively by selecting, listening and evaluating samples and arranging them on a graphic page, on which they could visualize and discuss their work" (p. 155). The teacher thus assumes more of a facilitator role for a creative process that cycles in a fairly straightforward manner through searching, listening and choosing samples, to phases of reflection and editing, to group agreement about sounds and compositional structure (Dillon, 2004). In sum, there is a need for differentiated teaching approaches when digital composition tools are used in interval-based and sound-based music education, respectively.

In terms of assessment, teachers' perceptions of musical creativity have been shown to vary according to "past experiences, current working context and teaching, and, potentially, any other musical activities undertaken outside school" (Odena & Welch, 2012, p. 43). For this reason, it is important that teachers have "practical knowledge of different musical styles in order for the knowledge to impact on their teaching" (ibid). Teachers' assessment criteria for composition work using 'looping' tools differ, for example, to allow for variation in student ability and musical knowledge (Wise et al., 2011). In a study of nine teachers working with *GarageBand* over a longer period at four different schools, teachers' perceptions ranged from skepticism about the creative value of working with pre-recorded loops and 'drag and drop' compositional approaches to endorsements of the software for allowing less advanced students to enjoy and complete composition courses without understanding Western music theory and notation (Wise et al., 2011).

Together, these strands of research show that the digital composition tools music educators use most frequently increase student engagement and learning in traditional popular music composition, and that sound-based music composition requires structured listening curriculum and learning activities. However, we also find that questions regarding *how* the design of digital composition tools in these respective domains support creativity in learning settings have not been sufficiently studied. Savage (2005) framed this challenge when writing that "the relationship between music and ICT is not one of servant and master, but rather a subtle, reciprocal and perhaps empathetic one" (…) and that technologies "could lead pupils and teachers to engage with and organise sounds in new ways, challenging the very nature of music itself at a fundamental level" (p. 168). More critical takes on this dynamic appeared early on (Folkestad, Hargreaves, & Lindström, 1998; Truax, 1986), voicing concerns that types of software might lead to shallow knowledge of sound fundamentals by limiting students' creative span to the affordances of the tools. Frustration in composing personal musical expressions due to genre limitations in software has been reported among students, showing that creativity can be encouraged but also constrained by tools and domain orientation (Cooper, 2009; Gall & Breeze, 2005). Such concerns are underpinned by studies showing that use of digital tools in music education mainly reinforces existing paradigms of interval-based music by facilitating more efficient production methods (Beckstead, 2001) rather than drawing on new affordances to transform learning and creative processes, e.g., the possibility to directly develop and change unique sound material, and to organize sounds according to principles and systems other than those found in styles of conventional pitch-based music.

Analyzing mediated processes of imagination and creativity

In light of previous research on sound-based and interval-based music education, we move to the question of how features of digital tools may be analyzed in terms of fostering and/or hindering creativity when learning composition in different musical domains. As Dobson & Littleton (2016) found in their study of higher music education, digital resources can mediate different types of 'possibility thinking' in composition work even when the tools are not physically present, e.g., students anticipating how they will be used, imagining solutions and how tasks will be divided, negotiating shared understanding of the tools and their affordances. Tool use is thus deeply embedded in composition work, although the mediating role of interactive software features often remains implicit when modeling creative processes (Gall & Breeze, 2005). Composition processes without technology are often represented as 'sequences' of activity with identifiable stages and types of thinking that one moves through to produce the creative outcome; studies of the "creative process in music as being divisible into certain 'types' of thinking (reflected in participants' on-task behaviour) has been a significant movement in the music psychology literature" (Hewitt, 2009, p. 4). Based on observations and other data collected from naturalistic settings, common types of composition procedures and phases have been described across individual, group, and teacher-led contexts. These often involve interrelated circular or recursive processes, e.g., “generating (playing with ideas, exploring, inventing, improvising), realizing (practicing, playing, establishing a fixed version, recording, transcribing, notating), and editing (manipulating, modifying, adjusting, evaluating, self-criticism, appraisal, aural judgment)” (Wiggins, 2007, p. 456).

Although research has identified general principles, concepts and procedures in teaching and learning composition, it has been argued that studies of imagination in creative processes must also include analysis of resources used for imagining, i.e. *sound material*. As Zittoun & Gillespie (2016) explain: “The specificity of the loop of imagination is that it operates with this material, displaces, condenses, transforms and makes it acceptable to the situated ongoing activity” (pp. 88-89). Therefore, to analyze the realm of ‘possibility thinking’ afforded by different kinds of digital tools we draw on models of creative processes in composition but also on perspectives on imagination that emphasize the mediating role of multimodal tools and the semiotic properties of the sound material, such as provenance (Gall & Breeze, 2005). The tools selected for analysis are *Apple’s* freely available *GarageBand,* ostensibly the most popular and common composition program used in classrooms worldwide, and *DSP*, a non-commercial composition program that combines synthesis and signal processing methods and has been used in Norway, Sweden, Denmark, the United States, Great Britain, Italy and Brazil. Both programs have been utilized in classrooms for more than a decade.

GarageBand as composition software for interval-based music

The software *GarageBand* has gone through significant changes since its launch as a bare-bones program in 2004, and is now (v.10.2.0) prominent in educational settings as a powerful Digital Audio Workstation (DAW) that teachers consider ‘easy to use’ (Vratulis & Morton, 2011). When starting a new session in *GarageBand*, the home screen appears with tracks and the instruments that can be mapped to them. The user selects instruments (sound samples) from a menu, and sets the time signature, tempo and key (Fig. 1). The instruments consist of synthesized or recorded loops, and the pitches can be keyed in or recorded from a MIDI device. The software provides the user with immediate sonic feedback, which can encourage inquiry about how to make and change the sound of the loop (Wang, Trueman, Smallwood, & Cook, 2008). The constructed loop may then be copied and moved, making it quite simple to produce a track.

GarageBand is bundled with sound files of different instruments from a large *Apple* 'ecosystem' library of premade loops, and add-on plugins and sounds are available from both *Apple* and third-party distributors. As a resource, the sound material is more concretely related to pop music than score-based art music. The instrument sounds can be adjusted somewhat by various dedicated tone controls, parallel to those found on the instruments or in normal studio use, although the ready-made samples limit the shaping of expressive qualities that are otherwise part of performances on acoustic instruments. The user composes while keying in or playing pitches on a digital instrument or on screen (Fig. 1), and an important feature of the software is an automatic drummer where the style can be configured in a somewhat flexible fashion. Sounds can also be recorded from a microphone into the program, but the possibility of importing sound files that are not part of the software package is not suggested in the library of instrument sounds, tracks, or the keyboard that maps computer keys to pitches. Should the user choose to import other sounds, they must be loaded into a record-preset track by way of Apple's *iTunes*. For imported sounds, default sound processing is limited to a compressor and an equalizer, and there is no provision for spectral manipulation or other radical sound-altering techniques.

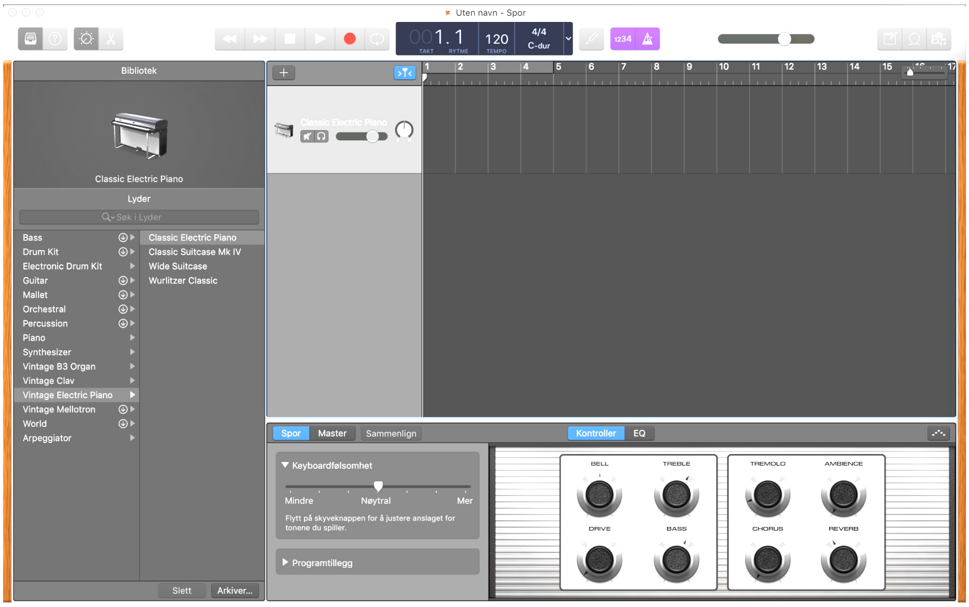

Figure 1. GarageBand startup screen showing instrument library. Screen shot reprinted with permission from Apple Inc.

Understanding imagination as a dynamic and mediated process (Zittoun & Gillespie, 2016), the composition process mediated by *GarageBand* is represented below (Fig. 2). The graphic interface *of GarageBand* is designed for selecting, listening and evaluating readymade samples ('loops') of musical instruments, referred to in the model as *concrete semiotic means*. The process is 'triggered' by curiosity and interest on the part of the user(s) in the situated context (Roth, Woszczyna, & Smith, 1996), or what Csikszentmihalyi & Hermanson (1995) call a 'hook' in their model of intrinsic motivation. Interest may be defined as a psychological state that develops in different stages, but generally refers to a liking, preference, or engagement with a particular content, in a given context, at a particular point in time, both individually and in groups (Valsiner, 1992; Renninger, 2009). The selected material is sequenced into melodic, harmonic and rhythmical structures in a musical composition, using playback to expand and develop the compositional idea by adding or removing material and changing settings for key and meter. The semiotic means, settings, and sequencing hierarchies are those most commonly found in interval-based popular music and establish the parameters for the generalization process and the compositional creative outcome. In sum, *GarageBand* is a tool that mediates the exploration of ideas in a familiar, well-structured and limited creative space, with the plausibility of mastering some of the hierarchic compositional conventions in popular music.

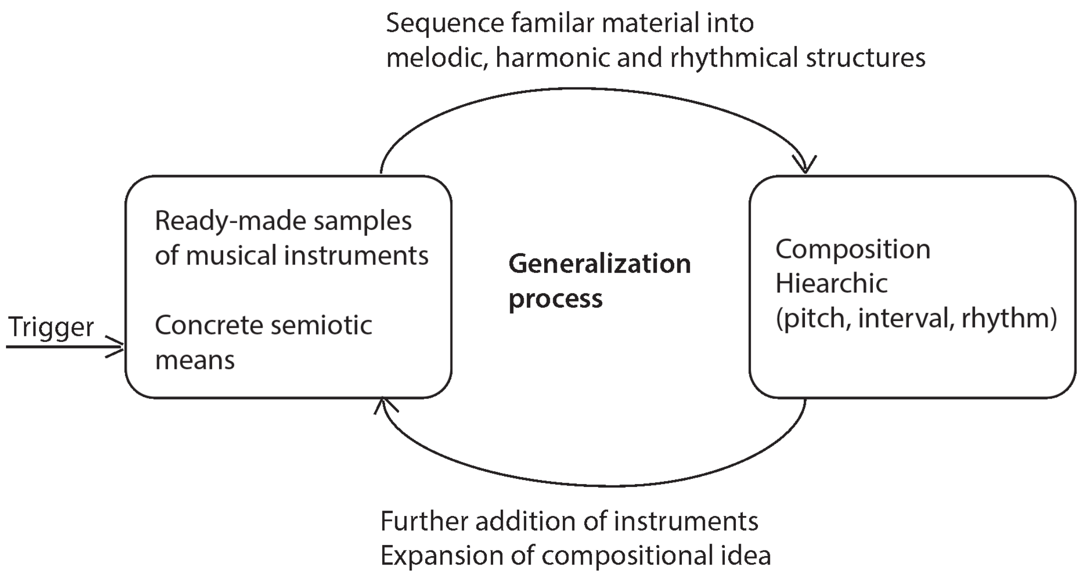

Figure 2. Imagination process mediated by GarageBand

The DSP sound-based composition software

The *DSP* home screen is also a mixer, and the user can choose to add tracks and to generate and process sounds from a menu bar on top of the screen. *DSP* does not have a fixed menu of instruments to choose from; the user has to either make a sound herself using one of the five sound generating programs or load a sound from a normal file dialog box. The sound material is placed into a mixing window for sound-processing work, which is divided into two menus (Fig. 3). The first contains common *effects* such as filters, chorus, delay, reverb, ring modulation and harmonizer, while the second *distortion* menu contains more unusual sound processing, such as granulation, stretch, scratch, spectral sieve and shift, plus algorithmic composition. The sound processing routines are grayed out until a sound has been selected. Sounds moved onto the tracks may be heard with instant playback, a crucial part of the creative process that is supported by both tools. However, unlike *GarageBand*, *DSP* does not feature selection and playback of samples of key, time signature and tempo (intervals or rhythms).

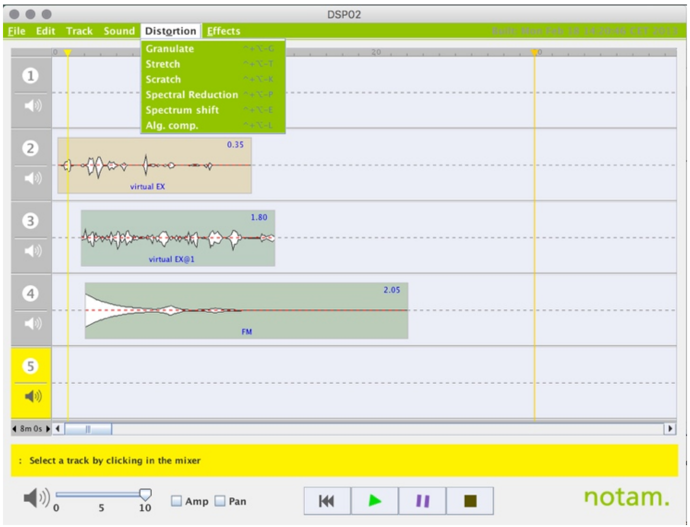

Figure 3. DSP screen showing Distortion menu

The composition process mediated by *DSP* is represented below (Fig. 4). Any kind of recorded or synthesized sounds may be used as semiotic means and 'trigger' for the activity of processing and developing composition material. The work of transforming and altering sounds is a specific process that disrupts their semantic and referential properties, thus re-contextualizing both the sound material and the composition task. Wolf (2013) explains: "In order to be able to listen for the musical parameters of a sound, it is necessary to learn not to focus entirely on the source of the sound. This separation of sound and sound source is a key skill that enables a different experience of electroacoustic music" (p. 127). The *abstracted semiotic means* create an imagination space, or generalization process, to explore changing symbolic and symbiotic relationships in a non-hierarchic compositional approach, expanding both the possibilities of musical material and the compositional idea. From a situated and domain-specific perspective on creativity in sound-based music, the 'loop' lies not in the tool but in imagination.

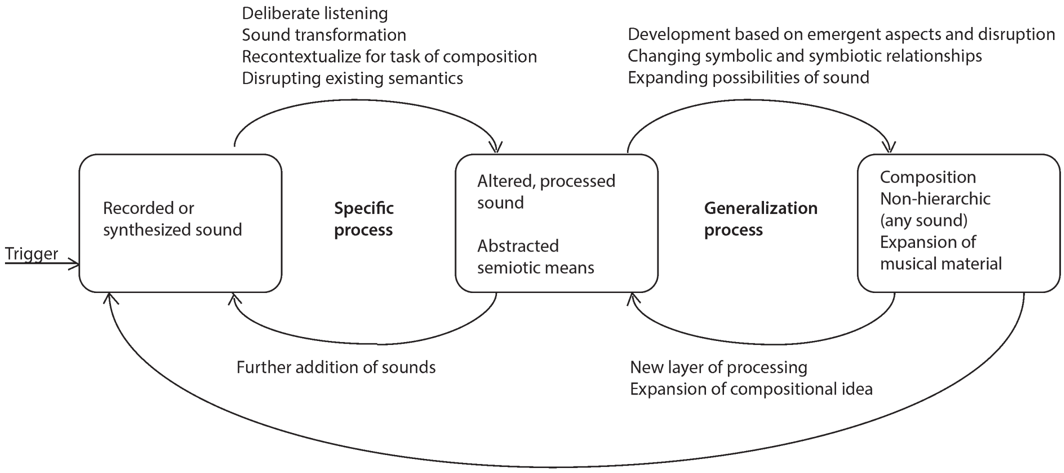

Figure 4. Imagination process mediated by DSP

Applying creativity models in sound-based music education

Working with curricular goals that emphasize learning and creativity, music educators include composition activities to facilitate students' imagination processes. Bringing teaching practices into focus, we present examples from data collected from a *DSP* workshop with high school students and teachers to illustrate guidance and facilitation approaches in different phases of the composition work. The learning and creativity goals for the workshop included of sound-based music as a domain; acquire technical skills in using sound-processing tools; develop knowledge of sound processing terms and effects; and produce a composition with aesthetics characteristic of sound-based music.

*Participants and data collectio*n

A high school class of twelve students (17-19 years old, 7 girls, 5 boys) participated in the workshop, which was led by two external teachers (T1 and T2, male). The class teacher (T3, male) arranged for the workshop as part of the Norwegian music curriculum and was present during the entire workshop, taking part in discussions. Responses to a post-workshop questionnaire showed that while none of the students were familiar with the domain of sound-based music, most had some experience with Digital Audio Workstations (DAWs), including tools for professional use (*ProTools* and *Logic Pro*). Students also had experience with the sound editor *Audacity*, notation software (*Sibelius* and *MuseScore)* and free software (*AudioSauna* and *GarageBand*). None of these programs were designed to support learning in sound-based music, although the general production software may be used that way.

Participant observations and video recordings were made of the entire workshop (approximately 6 hours) by a researcher who was also one of the teachers (T2, second author). The recordings captured whole class interactions as well as the interactions of one group of three students in particular. An interaction analysis approach (Jordan & Henderson, 1997; Derry et al., 2010) was used that entailed selecting excerpts of video, transcribing verbal utterances and physical orientations, and analyzing how these and other resources were made relevant in the students' imagination and composition processes. The data and excerpts were selected to provide a description of how teaching strategies were implemented in organizing the activities and used to facilitate learning and creative processes. In addition, sound files of students' works were collected to illustrate assessment criteria for sound-based music. Overall, the qualitative approach is in keeping with contemporary research methods in music education that aim for contextual and sociocultural embeddedness using observation, interview, and protocol analysis of verbal reports: "researchers have designed experiments, collected data in naturalistic settings, and engaged in work that lies along a continuum in-between experiments and naturalistic data" (Wiggins, 2007, p. 453).

Exemplifying teaching strategies in sound-based music education

Implementation and use

The organization of the *DSP* learning context was a one-day workshop held in an auditorium in the school. The room had a good sound system and screen projection but was not ideal in terms of flexibility in seating and circulation for collaborative group work. A 40-minute lecture by T2 introduced the class to sound-based music and its history, and included listening to works by Norwegian electroacoustic music pioneer Knut Wiggen. As discussed, when introducing sound-based music to students with no prior knowledge of the field, it is rare that the students immediately think of this as music at all. This was also the case in the workshop, as the students did not recognize the sounds as 'music' and did not immediately listen to them that way. Following the lecture, T1 moved immediately began a recording session involving the whole class to produce different sounds that could be used in their work. The students discussed which sounds they should make, and ended up with a newspaper headline that was read and recorded backwards and forwards. Smaller sounds, such as snorting, were also recorded. As soon as a sound was recorded by the teacher, he played it back for the class while editing and processing it using the DSP software, illustrating a range of effects. The students were clearly motivated by using their own recorded sounds as part of composition material, and they frequently referred back to the source material that they selected for their compositions. In this process, the students illustrate 'deliberate listening,' connecting the changed sound material with its origin, or provenance, while at the same time constructing new meaning as the spectral content changes character. The manipulation of the reading of the newspaper headline and the snorting sounds changed both articulation and voice quality, giving the reader (who the students knew well) a different personality and intentions. New meanings were created and further developed through deliberate listening.

When the students took a break, T2 copied the recorded sounds to the students' machines. Their next task was to explore how to use the program to process and structure sounds toward a composition. Although they seated themselves adjacent to each other and interacted in small groups, most of the students worked on their own laptops on individual compositions rather than collaborating. This was an extended, teacher-assisted exploratory phase in which the students used the software to select and transform sound material and experiment with developing the sounds into musical forms. This work was largely facilitated by the *DSP* program, which was primarily designed as an educational resource and provided learning materials in the form of help files and a website with a demo. The demo featured a piece of music that students could listen to and 'unpack' to understand each signal processing algorithm and procedure that was used in the composition, and they could also transform the composition using their own parameter settings. As discussed above, listening activities have been found to advance factual, conceptual and procedural knowledge and to foster creativity in composing sound-based music (Falthin, 2014; Holland, 2015; Wolf, 2013). In terms of teaching strategies, then, the organization of the learning activities – lecture, recording and listening activities, peer interactions, teachers, and DSP program – served as contextual resources to provide listening and procedural guidance for developing and exploring ideas in a new and open problem space.

Creativity and learning processes

As the students worked on their laptops they showed each other their screens and discussed their ongoing work, asking peers and teachers for technical assistance when needed. Students that did collaborate coordinated their work by filesharing and distributing tasks among themselves. 'Sharing sounds' was a general interaction pattern, both with each other and the teachers. This was often enacted wordlessly by taking off the headset, nudging someone, and handing the earphones to them to listen. Responses to such listening 'bids' often involved silent acknowledgement, perhaps an approving nod, and a return to one's own work, signifying mutual engagement in an ongoing compositional process.

Excerpt 1: Working with sound (specific process)

Tom (anonymized) has been working for about 15 minutes. He has asked the teacher for help about an error warning on the screen, shared this information with a fellow student, listened to a sound using his voice that the girls seated in front of him were using, and asked and received help from the teacher about how to copy and repeat a sound he has made. He found a file, opened it and is wearing his headphones to experiment distortion (Fig. 3). As he works, the teacher (T1) moves to stand behind him. After 15 secs Tom looks up at the teacher and takes off headphones.

1. Tom: A lot of fun stuff here (looking up at T1)
2. Teacher 1: Yeah
3. Tom: (…)
4. Teacher 1: Grain size - are you working with granulation?
5. Tom: Yes, the top one (pointing to a breakpoint curve)
6. Teacher 1: Granulation is a bit difficult to understand.
7. Tom: Yeah, I can believe that. Grain size, what is that?
8. Teacher 1: It is clipping sound into small pieces – how long the pieces are. A piece of a sound is called a grain.
9. Tom: OK
10. Teacher 1: Are they large pieces or small pieces…
11. Tom: I'll try some large pieces and see what that might be like then.
12. Teacher 1: Try to experiment a bit systematically with each parameter, it will be easier to make sense of it
13. Tom: Yeah

14. Teacher 1: I don't quite remember which frames you have but when we are talking about large sounds it is on a scale that is so big (shows with hands that the pieces are very small).
15. Tom: Yeah (continues to work, teacher leaves)

The first utterances in this exchange signal shifts in orientation, as Tom removes his headphones to acknowledge the teacher's presence and show that he is positively engaged in the task, volunteering that it is 'fun' material. The teacher notes that the grain size breakpoint curve window is open and asks if Tom is working with 'granulation' (line 4), which is a technical term for a specific signal processing routine. Tom responds affirmatively and points to the menu on the screen without elaborating. The teacher repeats the term and makes an implicit invitation to discuss its meaning in greater detail (line 6). Tom signals his uptake of the invitation by asking 'grain size, what is that?' (line 7). The teacher provides a definition, and Tom indicates his understanding by saying that he will continue by "trying some large pieces" (line 11). The teacher then suggests that a systematic approach to working with granulation can further clarify the concept. Following Tom's acknowledgement, T1 expands on his explanation by gesturing to clarify the relative scale of 'large' grains, which are actually quite small.

The excerpt illustrates how the teacher made himself available without being intrusive, focused the student's attention on a particular method, and introduced concepts behind sound-processing terminology relevant to the student's composition process. From a learning perspective, mastering the software does not require high level skills, and making sound files and controlling processing by using breakpoint curves does not necessarily evidence listening literacy beyond pitch, interval and rhythm. However, changing the semantic qualities of the sound material entails processes of interpretation and contextualization, as well as technical skills to extract and bring forward new sonic aspects from the initial recordings. Analysis of the material produced by Tom showed careful and deliberate sound processing, and sounds in his composition were more carefully crafted than the other student works. The sounds stand on their own, and are relatively refined in both construction and combination. His short piece from the workshop exemplifies a learning process and results that are more common in longer workshops, although it is evident that his creative work with the sound processing was more important to him during the allotted time than the aesthetic combination of sounds.

Toward the end of the day, T1 began to systematically request and collect students' productions. In this particular workshop, the teacher was also responsible for combining the student works into a whole class composition; a longer piece of music that would be performed at a public cultural event honoring Norwegian computer music pioneer Knut Wiggen the following week. Each student work was played on speakers for the class to listen to after it was submitted, and the teacher talked aloud as he further modified the work in real time playback, in a kind of 'mixing' activity for the longer class composition. In addition to making their own electroacoustic compositions during the workshop, then, the teacher and students were co-composers of a larger work, actively involved in listening and commenting on the development of the class's electroacoustic composition. T1 established his role and responsibility as lead composer for the class composition, engaging the students in informal dialogue as he talked about specific characteristics of the sounds and how they might be further transformed or amplified and reflecting aloud on how the different pieces might be arranged to relate to each other to create a single work.

Excerpt 2: Working with composition (generalization process)

Students invited teachers to give feedback on their compositions during different phases of their work, providing an opportunity to introduce aesthetic concepts relevant to the domain. Despite early technical difficulties that caused her to lose some of her work, Jill has worked enthusiastically and consistently throughout the day, talking and sharing work with two friends and the teachers.

1. Jill: (looks up, addressing the teacher) It's beginning to…
2. Teacher 1: Have you got something good? (Walks over, puts on headphones and listens. Smiles and gestures to the music while listening).
3. Teacher 1: (taking off headphones) I like that both the clapping and the voice don't stop, but keep coming in. This was really 'tough' (turning to Teacher 2) – have you heard this? Very insistent, in that there is something that repeats and repeats. The clicking sounds and a voice that says 'dishwasher, whoosh, whoosh, whoosh'
4. Jill: (loudly) No, it's Rachel saying "Dieselbot"
5. Teacher 1: And then there's a synth sound that (sings and gestures an upward glissando sound). And then it becomes different...
6. Teacher 2: (puts on headphones, listens, addresses Jill part way through) Depending on how long you use it, if you take it much longer than this you have to begin to introduce some kind of change or variation…
7. Jill: (…) Yeah, I began to take in alot more, but it…
8. Teacher 1: …the whole thing crashed?
9. Jill: So I have thought about it…
10. Teacher 2: (finished listening) And then you went up a halftone or something. It's smart what you do with several layers that are asynchronous – it is not the same between the layers, they shift in relation to each other. There is also something with the clicking,

suddenly there is a new version of it, more clicks. This is the beginning of something you could call a kind of 'element'.

In this exchange, Jill signals that she is nearing completion of her composition and wants to share it with T1, who is seated at front of class. T1 understands this as an invitation to listen to the work as a finished piece as well as an opportunity to provide feedback. He signals his approval by smiling and moving to the music, commenting on three sounds (clapping, voice, synth) and the way Jill has used them to create repetition (line 3) and variation (line 5) in the composition. He indicates ongoing engagement by addressing Teacher 2, extending the headphones and describing what he finds interesting about the use of sounds in the music. T2 puts on the headphones and tells Jill partway into the piece that change or variation may need to be introduced. Jill explains that this was her intent but there were problems with her computer crashing. When he is done listening to the piece, T2 uses specific terminology (asynchronous layering, going up a halftone) to describe compositional decisions that he thinks are "smart," and points out that the use of a particular sound Jill has made begins to work as a compositional "element."

Teaching and assessment approaches

In analyzing the teaching approaches, we found that in contrast to the teacher's focus on sound processing terms and effects in *Excerpt 1*, teacher discourse in *Excerpt 2* is concentrated on the student's compositional use of sounds, using aesthetic terms that are characteristic of sound-based music. Both excerpts illustrate a dialogic approach in student-initiated interactions that introduces domain-specific vocabulary *as it is made relevant* in the context of a student's work. As teaching strategies in technology-enhanced music education have shifted more from whole class instruction to individual process-oriented guidance, mastering such dialogic moves is increasingly important in all subjects (Major, Warwick, Rasmussen, Ludvigsen, & Cook, 2018). The excerpts also illustrate how listening is intertwined with a teacher's domain knowledge, specifically, an understanding of how a source material has been changed in the creative process. As with other art forms, domain knowledge is necessary in determining the value of the creative output.

The creative products were not formally assessed by the teachers in this workshop. However, drawing on established criteria (Wise et al., 2011), our assessment of the students' compositions focused on how clearly the material was structured, how much processing and editing had been done, the complexity of the outcome, the degree of variation and display of different approaches, and the overall coherence of the work. We found that while some compositions from the workshop were oriented towards semantic (or external) aspects of the material, others were more spectrally oriented, focusing on the processing, or internal connections, between the different elements. In a work titled *Grasshopper*, for example, a voice extract looped at different speeds was layered to craft an element of approximately 30 seconds. The work appeared as a very structured experiment that was given a musical form by layering effects and clearly noticeable differences between foreground and background. In another work, *Mixyeah*, the focus was on combining and layering to create a complex and intriguing discourse between quite simple elements. Both of these works combined sounds into larger forms and structures that extended the context of the sound material, an aspect of creativity and learning that requires technical and musical proficiency. Further, the forms and structures of the compositions show that the students understood aesthetic characteristics of the domain. An example of this is seen in the student work *Foisted*, which is unusually strongly oriented toward the action-consequence method often used to shape musical narratives. The narrative was developed further through sound processing, resulting in sounds that were different from the other sounds produced in the workshop. Overall, analysis of the creative products shows more of an emphasis on sound processing and less on composing, which is not surprising given that students need time to become familiar with the affordances of the tool before they can work with structure. As a result, the products appear more as experiments than finished compositions. Nevertheless, in the course of a few hours, the students learned about electroacoustic music and aesthetics, developed compositional ideas, and managed to inscribe them into a linguistic system of sounds using the *DSP* software.

Reflections and future research directions

This chapter presented a critical review of main topics in research on digital composition software in music education to investigate relations between digital tools, different musical domains, and perspectives on creativity and learning. Based on the review, we propose that a domain-specific perspective on the affordances and constraints of digital composition tools can help to understand their use in facilitating creativity and learning processes. Studies of teaching sound-based composition illustrate how an extended, abstract problem space allows students to deeply reflect on and engage with aspects of sound as imagination 'material,' supporting deliberate listening and triggering new ways of thinking creatively about music and composition. Analysis of students' and teachers' interactions during a workshop on sound-based music showed that young people in the period of a few hours learned about a new musical domain and were able to use a digital tool to compose music from sounds of their own making. In moving beyond the constraints of commonly used digital tools for composing interval-based pop music, the students experienced that when listening to their surroundings, 'the world may be musical at any given moment.' In this sense, the chapter echoes Burnard's (2009) call for a broad understanding of types of musical creativity, including individual, group, communal, empathic, intercultural, performance, symbolic and computational. This expansive perspective embraces sound-based musical genres and also invites further research about the scope and significance of aesthetic hierarchies embedded in music education (Kozbelt, 2017), in composition tools, and in the study of music as a domain of human creativity more broadly.

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