Making Digital Music Tools for Children

Jøran Rudi

The computer has become a musical instrument that is used in nearly every modern music production. The instrument works via software of varying complexity for professional and amateur use, and for composition with notes and recorded sounds. It changes pitch and timbre, it provides sound and control, and it supports structure and interaction. The computer has invigorated electroacoustic music, and has also been the basis of new technology-based genres such as electronic dance music (EDM) and the broad category of electronics. Despite this position in modern media production, educational music software for elementary and secondary schools hardly exists; any that is being used is often harvested arbitrarily from the World Wide Web, and not designed or constructed for pupils and young students. Students rarely develop any sort of musical or instrumental skills, nor any deeper understanding of what happens from a musical or technical perspective when they are using this software.

Digital technology for music education must be anchored to an understanding of technology, of music, and of educational science. These are prerequisites for broadening participation in the technology-based creation of music within a learning perspective. In particular, this is crucial for technology-based music, since the genres can't be taught without technology, while instrumental music can.

Technology-based music and, more narrowly, electronic or electroacoustic music, has for the most part historically been ignored by schools, despite its high relevance from both a technical and social point of view. After all, most music that the students made, we arranged nationwide competitions that only had interest in schools. In order to bring recognition to the children to explore and create, and to present their results in ways that are often described as necessary for full participation in society, in order to understand digital tools and avoid alienation. This was also one of our primary goals: to help children become comfortable with computers and digital representations, and, even better, to make them their own by creating something for their own consumption. Computer skills were not yet democratically distributed in society, and although many children had access to a computer at home, the number in the early 1990s was still less than half. In order to transform the experience of a technology from magic to logic, the user needs familiarity and practice, and creative activity is particularly valuable, as recent research confirms.

No technology exists in a vacuum. Its basis, development and implementation are shaped in social contexts, and the way it influences those contexts. Competence follows from the use of technology, and competence is so closely linked to the technology that it makes sense to see it as part of the technology, not separate from it. This way of understanding technology has been researched in several projects, and described in publications such as The Social Construction of Technological Systems. Neither are technologies neutral: they shape how we think about things, as well as how we actually do things, and this loop between thinking and doing depends on design. Where does the software encourage the user, and where does it stop him or her? How is the workflow designed? For NOTAM, these questions translated into the desire for simplification of the planned software, to avoid unnecessary ideas and functions that could confuse students and lead them away from the purpose of composition with digital tools.

Children's rapid appropriation of the new digital domain made it necessary to link the educational software and tutorial programme to wider society. We imagined this type of linking would be crucial for the software to be perceived as relevant for the target group, and decided that the software should draw on the aesthetics that the children were already exposed to – computer games. It would also need to be designed so that it would be attractive both in and outside of the classroom. We believed that learning from software and textual material should not necessarily be limited to the classroom, and today researchers look at this type of learning outside of formalised contexts as informal learning. Theory in this field is growing rapidly (as of 2015), as the focus broadens to incorporate exactly such game-based activities.

A key ambition for NOTAM was to increase visibility for the (at the time) new aesthetic domain of technology-based music – to allow the children to explore and create, and to present their results in ways that made it clear that they were taken seriously – not just as something that only had interest in schools. In order to bring recognition to the music that the students made, we arranged nationwide competitions and concerts at the Ultima Festival for Contemporary Music in Oslo.

NOTAM was established in 1992, and began its activities in January 1993. It was the composers' old dream of a national studio for electronic music brought to life, paired with emerging academic interest in digital tools for music. The need for building competence in the new domain of digital technology brought these divergent groups together, and their competence in digital music technology was for the most part limited to MIDI, which was a 1980s technology. Of course a few composers had briefly used computers for working directly with sound (not merely notes), but they were scarce.

Children had begun to develop what theorists today call ‘digital competences’ or ‘digital literacies’, and were typically more advanced than their teachers in developing these skills. Nowadays, digital competences are often described as necessary for full participation in society, in order to understand digital tools and avoid alienation. This was also one of our primary goals: to help children become comfortable with computers and digital representations, and, even better, to make them their own by creating something they could use. This way of understanding technology has been researched in several projects, and described in publications such as The Social Construction of Technological Systems. Further research into the impact of technology on education is ongoing, and new tools for children that the Norwegian Center for Technology in Music and the Arts (NOTAM) has undertaken since 1995, and the experiences and reflections which have emerged from this practice – from the digitally-pioneering days of the early 1990s until today. Furthermore, the increase in apps and browser-based software for children's musical play has brought several research questions to the fore, and these questions are important for assessing the creative and learning outcomes, in formal as well as informal learning situations.

The computer has become a musical instrument that is used in nearly every modern music production. The instrument works via software of varying complexity for professional and amateur use, and for composition with notes and recorded sounds. It changes pitch and timbre, it provides sound and control, and it supports structure and interaction. The computer has invigorated electroacoustic music, and has also been the basis of new technology-based genres such as electronic dance music (EDM) and the broad category of electronics. Despite this position in modern media production, educational music software for elementary and secondary schools hardly exists; any that is being used is often harvested arbitrarily from the World Wide Web, and not designed or constructed for pupils and young students. Students rarely develop any sort of musical or instrumental skills, nor any deeper understanding of what happens from a musical or technical perspective when they are using this software.

Digital technology for music education must be anchored to an understanding of technology, of music, and of educational science. These are prerequisites for broadening participation in the technology-based creation of music within a learning perspective. In particular, this is crucial for technology-based music, since the genres can’t be taught without technology, while instrumental music can.

Technology-based music and, more narrowly, electronic or electroacoustic music, has for the most part historically been ignored by schools, despite its high relevance from both a technical and social point of view. After all, most music that the students made, we arranged nationwide competitions that only had interest in schools. In order to bring recognition to the children to explore and create, and to present their results in ways that made it clear that they were taken seriously – not just as something that only had interest in schools. In order to bring recognition to the music that the students made, we arranged nationwide competitions and concerts at the Ultima Festival for Contemporary Music in Oslo.

The computer has become a musical instrument that is used in nearly every modern music production. The instrument works via software of varying complexity for professional and amateur use, and for composition with notes and recorded sounds. It changes pitch and timbre, it provides sound and control, and it supports structure and interaction. The computer has invigorated electroacoustic music, and has also been the basis of new technology-based genres such as electronic dance music (EDM) and the broad category of electronics. Despite this position in modern media production, educational music software for elementary and secondary schools hardly exists; any that is being used is often harvested arbitrarily from the World Wide Web, and not designed or constructed for pupils and young students. Students rarely develop any sort of musical or instrumental skills, nor any deeper understanding of what happens from a musical or technical perspective when they are using this software.

Digital technology for music education must be anchored to an understanding of technology, of music, and of educational science. These are prerequisites for broadening participation in the technology-based creation of music within a learning perspective. In particular, this is crucial for technology-based music, since the genres can’t be taught without technology, while instrumental music can.

Technology-based music and, more narrowly, electronic or electroacoustic music, has for the most part historically been ignored by schools, despite its high relevance from both a technical and social point of view. After all, most music that the students made, we arranged nationwide competitions that only had interest in schools. In order to bring recognition to the children to explore and create, and to present their results in ways that made it clear that they were taken seriously – not just as something that only had interest in schools. In order to bring recognition to the music that the students made, we arranged nationwide competitions and concerts at the Ultima Festival for Contemporary Music in Oslo.
and some concerts were broadcast by the Norwegian Broadcasting Corporation (NRK). In order to launch this ambition on a large scale in 1995, NOTAM also took the initiative to have the loudspeaker orchestra from Groupe Recherches Musicales (GRM) in Paris visit Oslo, in order to have the children’s works performed on one of the best available instruments for electroacoustic music. This and other concerts were produced in collaboration with the Concert Institute of Norway, a national organisation tasked with bringing contemporary music to school concerts.

In order to gain access to schools, our software and workshop programme needed to address the learning goals that were set out in the national curriculum. These goals were laid out in fairly general terms in programme needed to address the learning goals that were set out in the 1995 national curriculum. These goals were laid out in fairly general terms in the Ministry of Education’s revised learning plan L95; however the goals stated clearly that children should learn to compose, and investigate how, for example, sounds from nature could become music. The use of music technology was also encouraged. The description of these learning goals failed to address methods or tools, and that the implementation up to teachers who normally had low competence in the digital domain. NOTAM took the opportunity to define how electroacoustic and experimental music could be applied in schools, from software to practical implementation through classroom projects and workshops. Electroacoustic, or more broadly, technology-based music, had not yet been represented in schools across the country, but with digital technology becoming increasingly popular, it seemed timely to bring this music into elementary schools. The use of recorded sound and digital tools would open up possibilities for education, connecting across disciplines such as music, mathematics, physics, languages and social sciences. We wrote a series of suggestions for classroom projects for several disciplines where the software could be useful. Naturally, not all music education should revolve around information and communications technology (ICT) in general adds value. All these findings correlate well with our experience when establishing the workshop programme that has been running since 1996/7.

As part of the cross-disciplinary perspective, questions of learning were brought into the equation – how could children best develop their digital competence and become comfortable with the digital paradigm? Which skills should they have, and why?

Composition is often thought of as a solitary activity, for which the traditional cognitivist and constructivist models of understanding would be good frameworks for describing the meaning-making processes. We, however, thought of learning as something the students should do together – that their meaning-making should be developed during interaction between them, and in open workshop form. Theories such as Siemens later pointed out that technology has changed how we live, interact and learn, and that "Learning needs and theories that describe learning principles and processes, should be reflective of underlying social environments." Siemens uses the term "social connectivities" to describe this interaction.

The focus on process also entailed a focus on informal learning, where students would make something of their own by experimenting and developing their skills via their own activities, in or out of school. This type of learning is not prescriptive in the sense that goals for what the students should know by the end of the week are precisely described. Instead, goals are kept very general or are quite loosely articulated. However, in order to retain a stronger curricular focus, the learning process must be planned, and much can be done in deciding how the software should direct the workflow of the students. There were significant differences between the educational initiatives that were launched at approximately the same time as DSP. Meriton Subotric’s Creating Music software was oriented towards tonal composition but aimed for playful effortlessness without the use of notes. IRCAM’s 10 Jeux d’écoute from 2002 used forced moves in ten fixed audio games to take students through predetermined core topics; their perspective was linear, and correct answers were needed in order to progress to the next level. NOTAM’s software was more exploratory and game-like, but with constraints that made it much easier to work with synthesized sounds and signal processing than with notes, bars and metre. NOTAM’s software aimed to hold students within the new affordances of the digital domain without forcing procedural progress.

Unfortunately, there have been few studies of collaborative creative processes in music, despite the clear relevance they would have for the broader issues of technology-facilitated empowerment.

The software

In order to address the need for digital tools and basic computer skills, as well as prescriptive and non-prescriptive learning, NOTAM designed and produced the software DSP, which stands for digital sound processing. This term was not common at the time, but it pointed to the core of the project. DSP was designed to have the look and feel of a computer game, which made it stand out when compared to the primitive graphics and predefined learning goals that were normal in other educational software of the period. NOTAM’s software was the opposite, with a simple interface that took over the screen in the shape of a mixing window. The mixing window would always be open, and resembled an electronic instrument enclosed in a corrugated metal panel. These graphics, cutting-edge for the time, supplied extra references to things that did not normally appear in schools, and gave the software an out-of-class context. Drop-down menus were included in the window, shaped like electronic components, and the user interface did not reveal its Windows-basis. All the necessary choices for user interaction were placed inside the window, and this made the software easy to understand, much like the computer game functionality that children were familiar with; they of course had more experience with games than with standard computer software. When selecting either a synthesis or signal-processing subprogram (today they are called plug-ins in DAW-implementations), an instance of the subprogram would appear on top of the mixer window, and could not be moved to the background—it needed to be addressed and/or dismissed. No mistakes in the workflow were possible, and this was a method of controlling the workflow. When completing the operation in the mixing window, the resulting sound would be dropped into the mixer, where it could be freely moved around between tracks.

There were small animated elements on the drop-down menus which extended the feeling of a computer game, and animated buttons at the bottom of the window, as well as an animated fish that would glow during processing, and so on. Operations in the mixing window were controlled by animated buttons with the look of (somewhat unusual) cassette-player controls, which we found to be a familiar cultural reference for nearly all students. Changing parameter values in the subprogram window was done via breakpoint curves, for dynamic variation over the duration of the selected sounds. Initial parameter settings in all subprograms were important—they all sounded good when they were called up, and the allowed parameter range always kept the sounds within boundaries. This was a conscious design choice, since one could not expect much competence among teachers if a subprogram was to be set outside of audible range in one way or another. Nonetheless, the parameter space available to the young composers was larger than they could manage to fully explore, even with such limitations.

There were a few exceptions to this workflow design: the sound editor, a program for the simulation of reverberation (where the user manipulated the room size), and finally the help window.

The help window was unique in that it called another instance of the subprogram that it was called from, so that users could experiment live with what the help text suggested. This made the software easy to learn—not only could students read about what to do, but actually do it as well. One could also access all the text files via a menu, and the help files appeared through a deep adaptation of the Microsoft Explorer browser, where everything that could reveal the browser technology had been hidden.
This software was published on a CD-ROM for Windows, and since no schools had Macintosh machines at the time, this posed no problems.

In order to support teachers and particularly-interested students, we included tutorial texts, tasks for classroom use, and a computer music animation that was largely based on the author’s pioneering computer music animation work from 1995. When Timbre Comes Apart.\(^1\) The tutorial piece \& The Birds\(^2\) was made using just the DSP software, and mutually understood its affordances, it became clear that a higher-order common goal was needed – a reason for playing with the software. Workshop leaders would introduce musical tasks – forms and elements that depended on the overview of the workshop – some presentation on the spot from what the instructors had heard during the free exploration phase. These tasks would be combined in a variety of ways into collective compositions, or presented as standalone works, depending on the students’ skills and the methods they used.

The key idea was to have each student pair develop their work as freely as possible, and to help organize the results into forms that could be presented for the whole class, even for larger events such as festivals. In this manner, the workshops would be given at the start of the workshops, and the theoretical framing would reach beyond the individual to look at social interaction as well.

In brief, the functionality of DSP resembled what could be found at the time in professional software such as Ceres\(^3\) and Pro Tools, with music animation work from 1995, included tutorial texts,\(^13\) tasks for classroom use, and a computer music animation. In order to support teachers and particularly-interested students, we added for technology-supported music education, and for the development of ICT is considered pivotal to the development of future education. For example, the integration of the arts and interactive technologies is essential to the future of quality arts education learning for students in the field.\(^10\)

However, these are rather generalised statements, and although observation confirms their relevance, it is not clear exactly what type of ICT brings to arts education. Furthermore, most research on ICT and the arts tends to be focused on specific projects, and ICT is oriented towards note-based music and the tools that facilitate such an approach, while very little has been done on technology-based music.\(^25\)

1) Theoretical framing

The theoretical framing of how learning happens is necessary, and while the focus on individual meaning-making processes is important, it is equally important to recognize that technology has changed how we teach, and that technology is an issue. We need to think \& “Steemers” go on to explore theories which are most often used to describe it – behaviourism, cognitivism and constructivism – all were well developed before technology made the inroads into education that we see today. Learning is a culturally-conditioned activity, and the theoretical framing should reach beyond the individual to look at social interaction as well.

Rudi and Pierroux present a thorough description of this theoretical framing,\(^19\) while Dillon points out that there is a lack of research into the interaction processes in semi-formal and non-formal learning situations that involve computer and music technologies.\(^26\)

2) Electroacoustic music – an unusual instance or a unique combination of qualities?

Since current music technology is, with few exceptions, electroacoustic, it is an area of interest for many new ways of working with sound have been explored, in addition to (or instead of) other types of music. We believe that technology-based music is essential for music education, but we can’t answer the question until specific research has been undertaken to compare electroacoustic aesthetics with conventional acoustic aesthetics.

Is technology-based music just an unusual instance of music, or does it represent a unique combination of qualities? To put this another way, is this technology change meaningful, or just a new fad? As Mills and Murray ask which musical competences does technology-based music draw on?\(^16\) Which core values are operative, and how are they influencing meaning-making processes and benefiting a learning perspective? Are there interesting gene-distinctions, and are they important?

3) Creativity

Critical thinking and the ability to discern are at the base of creativity, and both rest on reflection. This iterative and recursive process encompasses creativity as an individual and a social activity, including both the executors and appreciators. The most important aspect is that it does not depend on predefined criteria for success – what is creative for one person might not be so for another. However, an approach as wide as this poses methodological problems for assessing the effects of different digital tools. One can for example, as per Coepe\(^27\), use reported frustrations with limitations in available software packages as an entry-point for understanding which compositional intentions could not be realised. Discourse analysis of the interaction between students will reveal negotiation themes and other interesting topics, and numerical methods may even weigh in, should the studies be structured around clearly defined and detailed questions.

4) Design of tools, workflow and interaction

Finale is the software that currently exists. Many of these apps are technology – assess the tools they find in the huge flow of apps and Web-based software that currently exists. Many of these apps are technology – or commercially-driven, and it may be difficult for the non-specialist to determine which tools may be the most appropriate for the task.

Software that currently exists. Many of these apps are technology – or commercially-driven, and it may be difficult for the non-specialist to determine which tools may be the most appropriate for the task.

Several limitations in software for combinatory exercises such as, for example, sampling programs where pre-recorded and edited sounds slip into tempo grids and pre-constructed shapes, make an effortless exercise void of musical learning or creativity.\(^28\) What is the significance of student influence on timbre, music type, pitch or melodic structures?

What does learning mean when combining tasks\(^29\)? Playful apps...
While the DSP interface had all the menus included in a game-like window, the interface of CwS combines a screen-based mixer window with conventional top-bar menus, so that users can choose how to operate the program. There are other differences as well, the most important being that CwS adds focus on a more structured learning approach, allowing the teacher to select subsets of functions in the software, and to conduct classes with stricter curricular goals.

This can be beneficial in classroom settings where the learning goals are more clearly defined, and perhaps more useful in some countries than others. There are advantages to both approaches, and it will be interesting to see the results as they arrive.

Despite the differences broadly outlined above, DSP and CwS are quite similar programs. It is clear that both point the students towards ‘classic’ electroacoustic music rather than EDM and similar genres, and both have fixed sound files as the end musical result. They are not oriented towards real-time composition, improvisation and performance, and in this sense they both ignore the real-time possibilities that current computing power easily delivers. Technology-based music has changed, and real-time electronics in semi-composed forms is more commonly the norm than the exception. This shift also needs to inform music education: smartphones and tablets are interesting platforms. Finally, considering the time the average student spends with social media daily, it seems impossible to ignore the potential benefits that this type of close communication can bring to compositional practice, with regard to interaction and participation across distance.

CwS has now become integrated into the EARS2 website, as described elsewhere in this journal, and this inclusion makes it part of the most powerful tool in existence for teaching what initiator Leigh Landy describes as “sound-based music.”

NOTAM’s most recent engagement with the development of software for education is as a partner in the European project Compose with Sounds (CwS). Having already developed working software for children, we were interested in the approach set forward by the project leader, Dr Monfort University. The differences between this new software and DSP are partly technical, partly educational. DSP, due to the hardware limitations of the mid-90s, replaced the original sounds with the transformed sounds and made much use of synthesis, while CwS has an updated technical solution and stronger focus on a structured learning approach. CwS draws on increased processing power to achieve its sound processing in real-time—the original sounds are not overwritten—and the focus of CwS is on music concrète and sound processing rather than synthesis.

The following algorithms are found in the software: Chorus; Flanger; Delay (including Doppler and resonant filters); Harmonizer; Filter (Highpass, Lowpass, Bandpass and Bandstop); Reverb (constructed through room simulation); Ring Modulator; Slicer; Spectra Shift; Time Stretch; Granulation; Synthesis (Additive, FM, Plucked String, Buzz, Noise); Recorder; Sound Editor; Reverse; Scratch; Algorithmic Composition.

The following tutorial texts are found in the software: ‘The History of Electroacoustic Music’; ‘What is Sound?’ (simple acoustics, frequency and amplitude); Sound in the Environment; Harmonics and Spectra; Sampling (how sound is represented in the computer); Synthesis (musical signal processing); Working with Sound; Working with Notes; Algorithmic Composition; Cross-Disciplinary Common Characteristics Between the Arts; Real-Time MCE Performance; Technology in PayRock Music; Computer Music Animation (movement through spectra).

3. CwS is the name of the institution created by Pierre Schaffer around musique concrète.
10. For example, Theresa Dillon observed that “it is a distinct research gap to find real user-case studies, answering the question of how user input re-shapes the original ideas, complementing the specialist perspectives.”
11. Without updated music education with research-based focus on the genres of technology-based music, music in schools will clearly lose their relevance for students, and the consequence is that music will not appear to be taken seriously. That may be a loss that we can poorly afford to sustain.

Jøran Rudi