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Computer Music Composition for Children

Music education in elementary schools often lags behind contemporary requirements in terms of aesthetics, methods, and technology. These concerns have been raised, resulting in the restructuring of educational plans to include music composition and the use of music technology by children. Using computers to implement these changes seemed a valid solution that would enable the introduction of contemporary electro-acoustic composition methods and the promotion of creative sound exploration. However, the available commercial software solutions for teaching music composition had various limitations in terms of educational models and musical styles.

In this article, we discuss a software tool for music composition known as DSP. Developed by the Norwegian Network for Technology, Acoustics, and Music (NOTAM) to address the limitations of existing commercial solutions, DSP is a Java-based tool that combines digital signal processing, composition, and tutorial materials into one package that can run in any browser on any computer platform. DSP is freely available for download on the Web (http://www.notam02.no/notam02.no). In this article, we discuss the challenges of teaching music composition, computer-based music composition solutions to address these challenges, and the educational model, algorithms, implementation, release, and future enhancements of DSP.

CHALLENGES IN TEACHING MUSIC COMPOSITION

The biggest challenge in teaching music composition in elementary schools is conveying a sense of relevance to the target group, supported by teaching methods that address common musical conventions as well as the aesthetic developments that break these conventions. To achieve this goal, the computer is considered to be a musical instrument and is brought into the classroom. This step not only challenges traditional ideas about music and music composition but also opens new possibilities for musical work, such as the learning of electro-acoustic methods. These methods have long seemed inaccessible to broader audiences because, according to computer music composers, most people are not trained to "listen" beyond classical forms. Hence, teaching children electro-acoustic methods can significantly impact their appreciation of contemporary forms and, in the long run, can impact computer music itself as some of these children become composers.

COMPUTER-BASED MUSIC COMPOSITION

Computational approaches to music composition present several advantages. First, in contrast to traditional note-based composition, computer tools allow direct manipulation of the sound material, thereby providing immediate feedback and implicit encouragement to the students. Second, the computer allows for detailed work with recorded and synthesized sound, encouraging the students to bring in their own sound material. Third, depending on the music representation used in the software, the computer tools easily enable editing of compositions and therefore increase efficiency. Fourth, digital tools in general and digital musical tools in particular also encourage cross-disciplinary work with graphics, video, and other media.

A JAVA TOOL FOR TEACHING MUSIC COMPOSITION

In 1996, the opportunity to design a software tool for music composition to bring the advantages mentioned earlier into the children's music learning process appeared in Norway in response to the changes in educational plans for elementary schools. The new plans stated explicitly that students from fifth grade up until age 16 should learn music composition using technology/computers. The plan was very ambitious, given that there existed sparse computer resources and competence in music technology among the teachers who taught at these levels, as well as limited availability of software in Norwegian for children.

CONTEXT

Previous experiences have been valuable when approaching the DSP design process, as we learned that the linearity of the educational tools for children and the paint-by-number approach to aesthetic exploration and development skills were limiting. Linearity referred to the fact that, even though digital educational tools for children were not common, the ones that existed required students to provide correct answers in order to proceed further with the software. From experience with composition and performance of music, we found this linearity to be restrictive to the creative impulse. The paint-by-number approach referred to the increasingly popular "aesthetic standardization" stemming from the use of sequencers [software organizers of musical notes on tracks, as in a musical score, assigning different instrument sounds to the tracks; sequences are supported by the musical instrument digital interface (MIDI) protocol] as common tools for the organization of sounds and the use of

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ready-made samples in the software for rhythmic music composition.

EDUCATIONAL MODEL

The educational model employed in DSP features a number of desirable characteristics.

- *It resembles professional software for music composition*. We developed a software model for education that addresses the linearity limitation and resembles professional software approaches for computer composition, such as signal processing software (e.g., Ceres) and screen-based mixers (e.g., ProTools [1]).
- *It uses advanced and complementary software tools for exploration*. We employed advanced software tools for exploration and play, intended to address the paint-by-number approach limitations and complement other tools that teach music in a more traditional framework (with notes or other types of iconic representation) [2].
- *It uses a student-centered learning perspective* [3]. We selected a nonlinear model, which allows the software to be understood by students through curiosity and compositional tasks. This model places the students in an investigative education situation, where they need to learn how to master the software, use the methods in the software, understand terminology, and understand the purpose of the software in order to construct meaning. Consequently, the graphical user interface, graphic elements, language, and demo files were carefully designed to facilitate creative explorations.
- *It involves limited formal musical training*. We used the assumption that composition will be taught without much formal knowledge of musical form or notation, given the abstract nature of electronic music and the low level of knowledge in this field among the students. The idea was that the students should be able to play with the tools and be productive without being concerned about providing correct answers or sticking to stylistic blueprints. The students should explore, synthesize from their experiences, reflect upon their results, and construct knowledge from the process [4].
- *It focuses on simple operations and an appealing graphical user interface (GUI)*. We focused on simple operations and an appealing GUI to reduce, as much as possible, the time required to learn the software. One could expect children to spend less than three hours with the software in a normal school year, unless the school had decided to implement other special projects. With this amount of time available, the learning curve for the software could not be steep, and it would be beneficial if the software used familiar GUI elements and interactions.
- *It makes available a multilayered, interactive help system*. We integrated the help and text files in the program to keep the learning threshold low, while strengthening the focus on exploration rather than learning of traditional musical form and composition in different styles. This idea proved to be a very efficient aid in the learning process.
- *It draws on interdisciplinary perspectives*. We included accompanying texts that pointed to the relevance of the software for such related fields as physics, mathematics, and social sciences. Sound exists in both the natural and manmade world, and it can be analyzed and understood as a cultural, biological, and physical phenomenon, obeying the laws of acoustics and perceived through the biological and cultural filters of psychoacoustics.

ALGORITHMS

The current DSP algorithms are included in Table 1. We combined the algorithms to provide a practical package for both signal processing and composition, while including the most common methods. We kept spectral-domain manipulation methods to a minimum because of the computational cost, and we did not include external controllers and real-time processing of audio streams. We included texts for "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," "Working with Sound vs. Working with Notes," "Algorithmic Composition," "Real-Time MIDI Performance," "Technology in Pop/Rock Music," and "Computer Music Animation."

GRAPHICAL DESIGN

To increase the educational impact on the students, we designed the first version of the software tool to resemble a game by providing a look "into" the action area by a surrounding frame and providing simplicity in both the graphic design and the user interaction. The visual references of the GUI pointed to rusty and used metal, with a three-dimensional look and a few animations in the foreground to enhance the aesthetics and the sense of depth. The intention was to make the software stand out from the more common educational designs and to make the software look attractive to the young student target group. As illustrated in the screenshot in Figure 1, a five-track mixing window opens when the program starts. The window contains buttons for pulldown menus for the different DSP routines and GUI elements for operating the mixer window. The user can synthesize, import, or select sounds in the mixing window for processing. All DSP routines open on top of the mixer window and have a similar interface, although the number of parameters varies with the DSP algorithm. We designed the system such that the number of parameters available to the students is low and presets and value ranges are usually provided. The help buttons link to fully interactive new instances of the particular programs, opening on top of the existing mixer, program window, and help text.

IMPLEMENTATION AND RELEASE

The first version of the software was produced in 1996 [5], with the goal of running efficiently on the relatively slow CPUs that were available at the time. The programming languages used were C++ and Delphi. The implementation targeted Windows platforms because these were the most commonly used in

Norwegian schools. The software was published on a CD-ROM for Windows 95/98 and included help texts, tutorial texts about a wide range of topics, and a computer music animation [6].

The software was ported to Java in 2003. At the same time, the software was redesigned and packaged to run in any browser after downloading the Jsyn library from Softsynth. The software could also be downloaded and run locally without a connection to the NOTAM Web site. The software was initially released in Norwegian, Danish, and English versions. The software has recently been translated into French and Swedish, and it is in use in school projects in these countries as well.

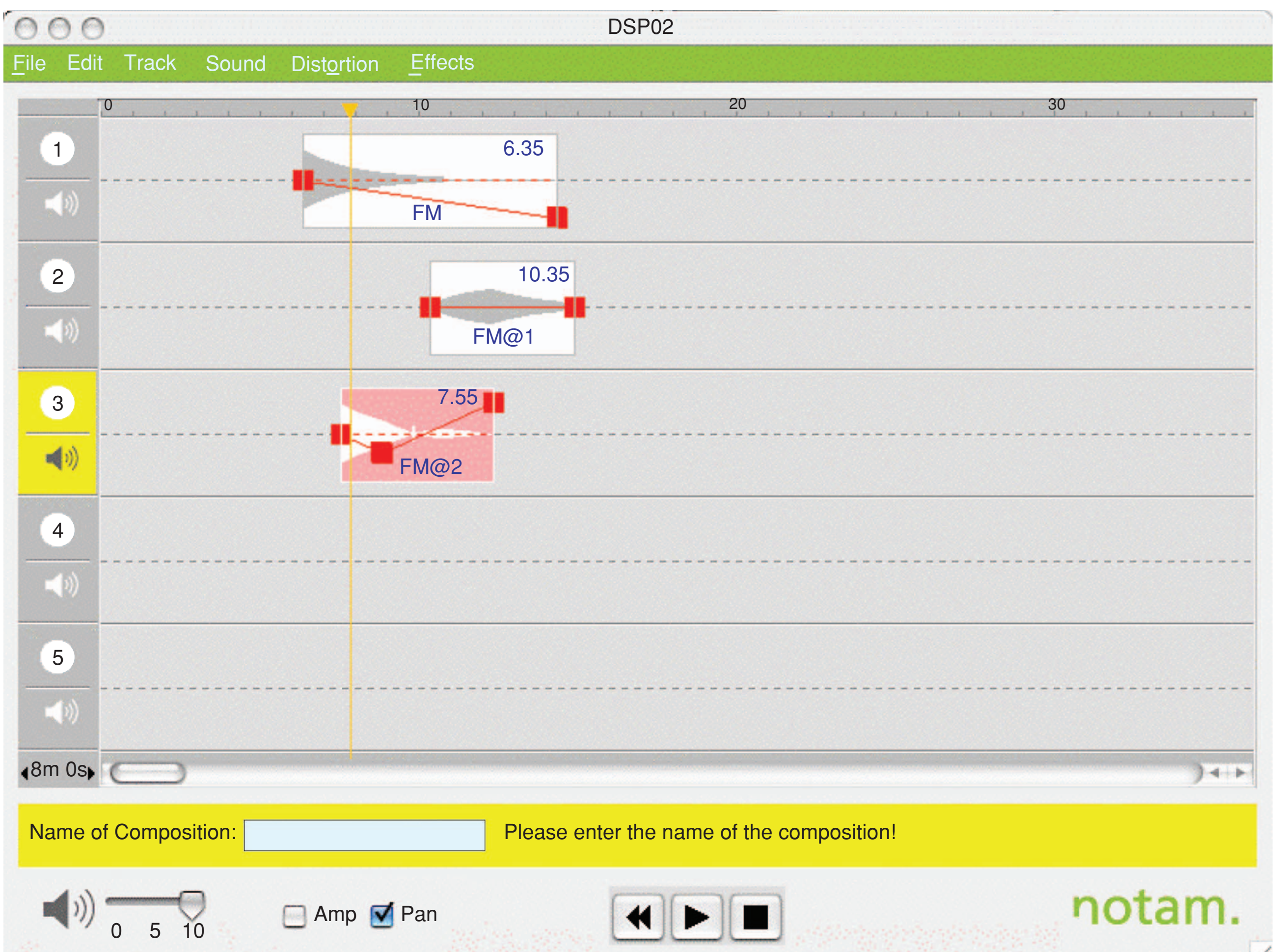
EVALUATION

The innovative and nondogmatic approach to music composition has contributed significantly to DSP's popularity. Every year, hundreds of students use the program in the musical projects organized by NOTAM, while others employ it for musical projects ranging from simple two-hour workshops to the production of more comprehensive concert events including dance, live video, and other real-time elements.

The workshops that we developed were organized with two or three students per machine under the musical guidance of workshop leaders and/or teachers, ensuring that students had the opportunity for discussion during the sessions. The workshops promoted collaborative problem-solving, engaging and stimulating the multiple intelligences that are employed in music as a social activity [7].

Concert events held as part of school shows or integrated in professional performances built upon the social aspects of music and music-making; they strengthened the interest and determination of the students and helped recognize their work in the local communities. National recognition has been secured through participation in major music festivals and broadcasts by the Norwegian Broadcasting Corporation, making music education more meaningful by increasing its relevance to a wider community.

Although no formal studies of DSP use have been conducted, there are numerous observations and project reports available to confirm that students learn music better when working in groups and with an instructor; music at this level seems to be best taught as a social activity. A systematic evaluation of the workshop and project model is underway. This evaluation will



[FIG1] Screenshot of the mixing window, with three sounds in rectangular boxes and red breakpoint curves for placement of the sounds in the stereo image.

[TABLE 1] ALGORITHMS IN THE DSP SOFTWARE PACKAGE.

ALGORITHM	MEANING
CHORUS	MIXES SEVERAL DELAYED VERSIONS OF THE SAME SIGNAL TO MAKE ONE SIGNAL SOUND LIKE A WHOLE CHORUS
FLANGER	COMBINES A SIGNAL WITH A VARIABLE TIME-DELAYED VERSION OF ITSELF
DELAY	PLAYS THE ORIGINAL SIGNAL TOGETHER IN COMBINATION WITH A DELAYED VERSION OF THE SAME SIGNAL
HARMONIZER	PITCH-SHIFTS A SOUND WHILE KEEPING ITS DURATION
FILTER	INCREASES OR DECREASES THE AMPLITUDE OF FREQUENCY AREAS
REVERB	SIMULATES THE BEHAVIOR OF SOUND IN A ROOM
RING MODULATION	MULTIPLIES TWO AUDIO SIGNALS
SPECTRAL SIEVE	FILTERS A SOUND BY REMOVING WEAKER PARTIALS
SPECTRUM SHIFT	ADDS A NUMBER TO EACH PARTIAL IN THE SPECTRUM
TIME STRETCH	CHANGES THE DURATION OF A SOUND, WHILE KEEPING ITS FREQUENCY
GRANULATION	DIVIDES THE SOUND INTO UNITS WITH VERY SMALL DURATION, AND ALLOWS FOR DIFFERENT METHODS OF RESTRUCTURING OF THESE UNITS
SYNTHESIS	GENERATES SOUND FROM MATHEMATICAL MODELS
SOUND EDITOR	REPRESENTS THE SOUND IN THE TIME DOMAIN, ALLOWING FOR CUT AND PASTE OPERATIONS AND CHANGES IN AMPLITUDE
REVERSE	PLAYS A SOUND BACKWARDS
SCRATCH	ALLOWS ONE TO CHANGE THE DIRECTION OF PLAYBACK OF SOUNDS
ALGORITHMIC COMPOSITION	MAKES MUSICAL STRUCTURES FROM MATHEMATICAL MODELS

attempt to establish more precisely what type of composition and listening skills the students develop during work with the software tool, and the results from this evaluation will be used for further development of workshops and school projects.

FUTURE ENHANCEMENTS

The DSP software is now almost ten years old, and it is clear that its founding idea is still relevant. However, the program needs to be constantly updated, both technically and aesthetically, to keep the educational tools in touch with the aesthetics and production methods of contemporary music. For example, the sample manipulation software methods with ready-made samples (which did not exist when DSP was created) have contributed to a stronger focus on rhythmic sampling in broader groups. Other methods that would be useful to incorporate in the DSP tool are feature-driven processing and resynthesis. We believe that the implementation of methods that are less exploited in the commercial domain will continue to give DSP an edge in comparison with typical sequencers and plug-ins. New Web enhancements that are foreseen include systems for storing and distributing sounds and compositions among software users and for encouraging distance communication as part of school projects.

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Jøran Rudi (joranru@notam02.no) has been the director of Norwegian Network for Technology, Acoustics, and Music (NOTAM) since 1993. He has written music for dance, film, performance art, and multimedia, and his music is performed worldwide.

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Additional materials and software for download are available at http://www.notam02.no/notam02.no [SP]

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