A VIRTUAL COLLABORATIVE LEARNING ENVIRONMENT

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Abstract

This paper presents a virtual learning environment developed for music education and includes both individual and collaborative interactive environments. This learning environment is a music composition edutainment software, which is being developed in collaboration between the University of São Paulo, Laboratório de Sistemas Integráveis (LSI) da Escola Politécnica da Universidade de São Paulo (USP) and the São Paulo State Orchestra, Coordenadoria de Programas Educacionais da Orquestra Sinfônica do Estado de São Paulo (OSESP). Recent research in music education as well as new computer and telecommunication technologies are being applied in order to offer creative virtual learning environments to the students and offer pedagogical tools to the teachers.

Keywords

Virtual learning environments, Computer supported collaborative learning, Distance education, Music education.

1 INTRODUCTION

This paper presents a virtual collaborative learning environment developed for music education. The main characteristics of the developed software are interactive environments for individual users and interactive collaborative environments for groups of users connected in a local area network or geographically distant and connected by a wide area network, so that it can be considered a distance education tool. The software is being implemented by the LSI and is part of a set of technological projects of the OSESP educational programs, which includes the presented project: a musical composition software for children and teenagers. The software follows the constructivist and collaborative learning theories.

In the next section, we initially describe the theoretical aspects used to establish the characteristics in each of the relevant areas. In section 3 we detail the virtual collaborative environment, in section 4 the technological infrastructure, in section 5 the methodologies we used and in section 6 we present the test results.

2 THEORETICAL ASPECTS

2.1 Constructivism in Educational Software's

Recent research in education points to the constructivism theory as a valid and suitable learning theory, in which the teaching/learning process concentrates on the student, so that the student constructs his/her knowledge by the means of experience, as an active element of the process, guided by his/her teacher.

Computational power and especially multimedia resources enabled the development of educational applications based on the constructivism theory, with which users control the interaction rhythm, manipulate and assimilate knowledge. Contents, as well as creative environments, may vary so as challenges that present some form of prize after tasks are executed. [Druin99] [Squires94]. These applications concentrate on the way the concepts are presented to the user rather than on the concepts themselves [Casas96].

Challenges must correspond to users ages and capabilities, they must be stimulating enough yet not too difficult to solve. Students' motivation can be maintained using animations, encouragements, spontaneous help, prizes and progress visualization. Many educational applications offer limited interaction possibilities between teacher and little interaction between students.

Knowledge construction does not exclusively depend on teaching methods but also depends on the interaction between the teacher and the students as well as interactions between students. Collaborative learning is fundamental no matter what subject is being studied [Zeve00]. An educational application that offers collaborative learning environments delegates authority to the student and his colleagues and encourages idea elaboration and evaluation [Landow92] [Dufty96].

The computers processing capabilities can help students construct their knowledge; abstract concepts can be graphically represented and manipulated by the students so that they can construct their knowledge by the means of experience [Kozma91].

2.2 Distance Education

Distance education is one of many computer supported educational environments and can be characterized by the physical separation between the teacher and the students in geographically distant nodes [Keller99]. Distance education stimulates experience driven autonomous and independent learning, respecting the students study rhythm, making the students active subjects in their education. Also, distance education democratizes access to education, enables greater knowledge diffusion, prevents student transportation and diversifies course offers.

Nevertheless, distance education requires specific methodologies since the teacher does not see the students' reaction and therefore has a certain difficulty in maintaining their motivation. Generally distance education does not meet the social objective since students are isolated in geographically distant points; there is no direct experience exchange between teacher and students or between students and this affects collective knowledge construction [Simonson00].

2.3 Music Education Pedagogical Structure

A pedagogical framework that guides the development of a music education software, must contemplate educational and technological aspects combining a learning theory and a model of music education to explore the new computer and telecommunication available resources.

In musical terms, we can observe Swanwick´s point of view presented in the C(L)A(S)P Model [Swanwick79]. In this model, Swanwick identifies five ways in which people relate to music: Composition, Literature studies, Audition (or Audience-listening), Skill acquisition and Performance. These constitute the five parameters of musical experience. Composition, Audition and Performance are primary activities in musical development since they allow a direct involvement *with* the music (knowledge *of* music). Skill acquisition and Literature studies have more supporting and enabling roles, since they provide knowledge *about* music [Swanwick79].

According to the author, composition includes all forms of musical invention, which can be a small phrase or a genuine invention [Swanwick79]. Composition occurs when the student creates a musical event, by choosing and ordering the musical elements in an expressive way.

According to [Hentschke96] [Hentschke97], musical composition is the best way to acquire musical knowledge since the individual is able to make decisions and transform the musical object.

2.4 Computer Supported Collaborative Learning (CSCL)

This research area concentrates on several subjects like: the comprehension of learning as a collaborative process that is society-dependent and culture-dependent; the development of technologies that mediate collaboration; the development of collaborative learning evaluation.

According to [Kumar96], collaborative learning concentrates on the educational methods that promote collaborative tasks so that groups of students work together on the same task. CSCL systems are passive, therefore these systems do not actively control the collaborative interactions, but they provide means so that these interactions actually occur.

When developing a CSCL system, some basic characteristics must be contemplated [Kumar96]:

- the *Interface* must support interaction between students and be adapted to the study domain;

- the *collaboration modeling* must be represented in terms of conflicts and decisions; students with different roles must be modeled in different ways;

- the *collaboration coordination* must be implemented: users roles, coordination and administration of these roles.

3 THE VIRTUAL COLLABORATIVE LEARNING ENVIRONMENT

The virtual collaborative learning environment is implemented as a musical composition software that uses recent information and telecommunication technologies to create virtual interactive collaborative learning spaces that support teacher-student interaction as well as student-student interaction.

The software's main objective is to develop musical knowledge through musical composition and to stimulate the interest in learning music. The software is aimed to be used by non-music literate students. The proposed interactive environments offer virtual spaces where students develop their creativity, where they experiment music composition and evaluate their work (constructivism) and where they interact with other students and teacher (collaborative learning).

3.1 Operation Modes

The musical composition software includes several different environments here named 'operation modes' which include 'composition modes' and 'challenge modes'. Composition modes are free environments in which the students are stimulated to use their creativity and experiment making music or composing melodies. Challenge modes are directed or restricted modes where students are confronted with an exercise, previously prepared by their teacher, and which they try to solve.

Figure 1. shows the software's six different operation modes. The individual modes are for students who interact alone with the environments. The collaborative modes grouped as 'Rede Local' in figure 1, are environments used by users connected to a LAN (Local Area Network), where each user is connected to a workstation and where groups of users work together in virtual interactive environments. Users connected through a WAN (Wide Area Network) to the OSESP server, can use the collaborative modes grouped as 'Rede OSESP' to work together with geographically distant users in virtual environments.
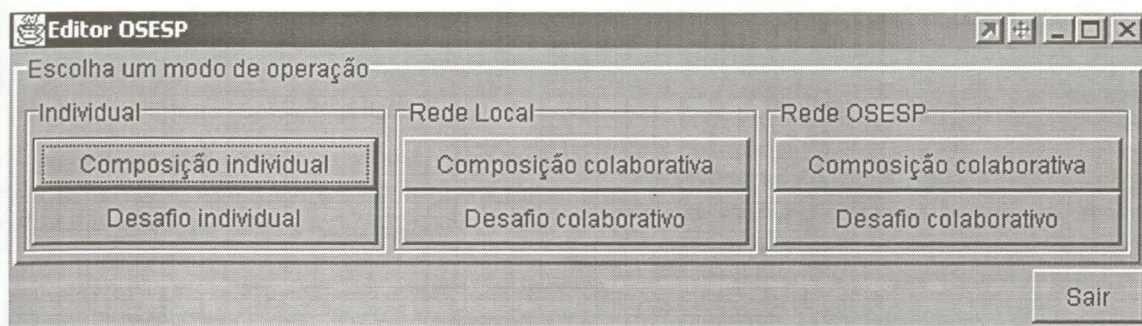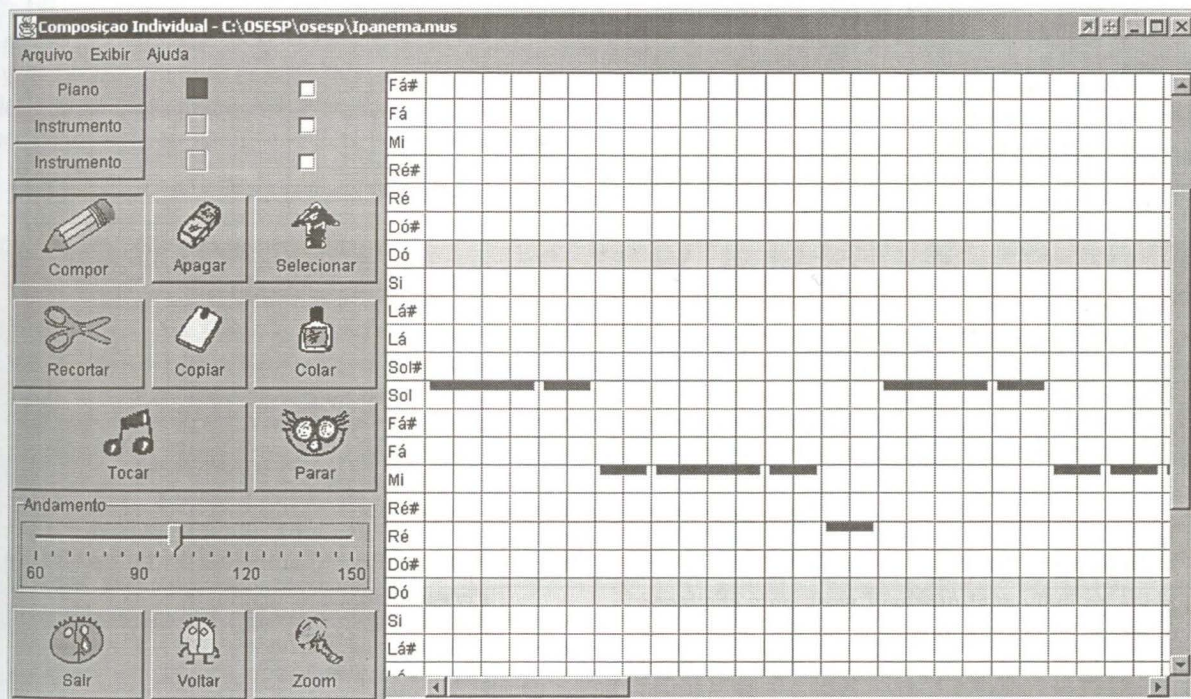
Figure 1: Operation Modes

Figure 2: Individual Composition Mode

3.2 Individual Composition Mode

Using the Individual Composition Mode a user can experiment making music with different instruments, can listen to the composed melody and evaluate the result. The user can save the composition in a special format that can be opened and continued later.

Figure 2. shows the interface of the Individual Composition environment. Users choose a tool from the tool bar on the left side of the screen and can compose a melody on the grid on the right side of the screen. Typically the user chooses one, two or three instruments (in this case the user chose the piano), the software automatically returns a color that will identify the instrument in the melody (in this case pink), then the user 'composes' a melody painting the grid. The grid represents the staff, so that the horizontal axis represents the time line and the vertical axis represents the musical notes. The tool bar includes various editing tools such as: compose, erase, select, cut, copy, paste, play, stop, tempo, exit, back and zoom. Users use these tools to compose, to edit and to hear their compositions. The

menus on the menu bar enable file saving and opening, viewing or hiding the notes list on the left side of the grid and viewing on line help information.

Rather than the conventional musical notation, this simplified notation was adopted so that non-music literate users can easily use the software and experiment making music.

Each time the user adds a note on the grid, the computer reproduces the sound of the chosen instrument playing that note.

When the user activates the 'play' tool, the computer reproduces the entire melody that was composed on the grid, highlighting the notes that are being played at the time they are played. Therefore students can think over and improve their composition.

Another interesting feature is that when a user composes a melody by a certain instrument, let's say the piano, and then wants to hear the same melody played with another instrument, let's say a trumpet, the user just changes the instrument on the tool bar from piano to trumpet and activates the 'play' tool.
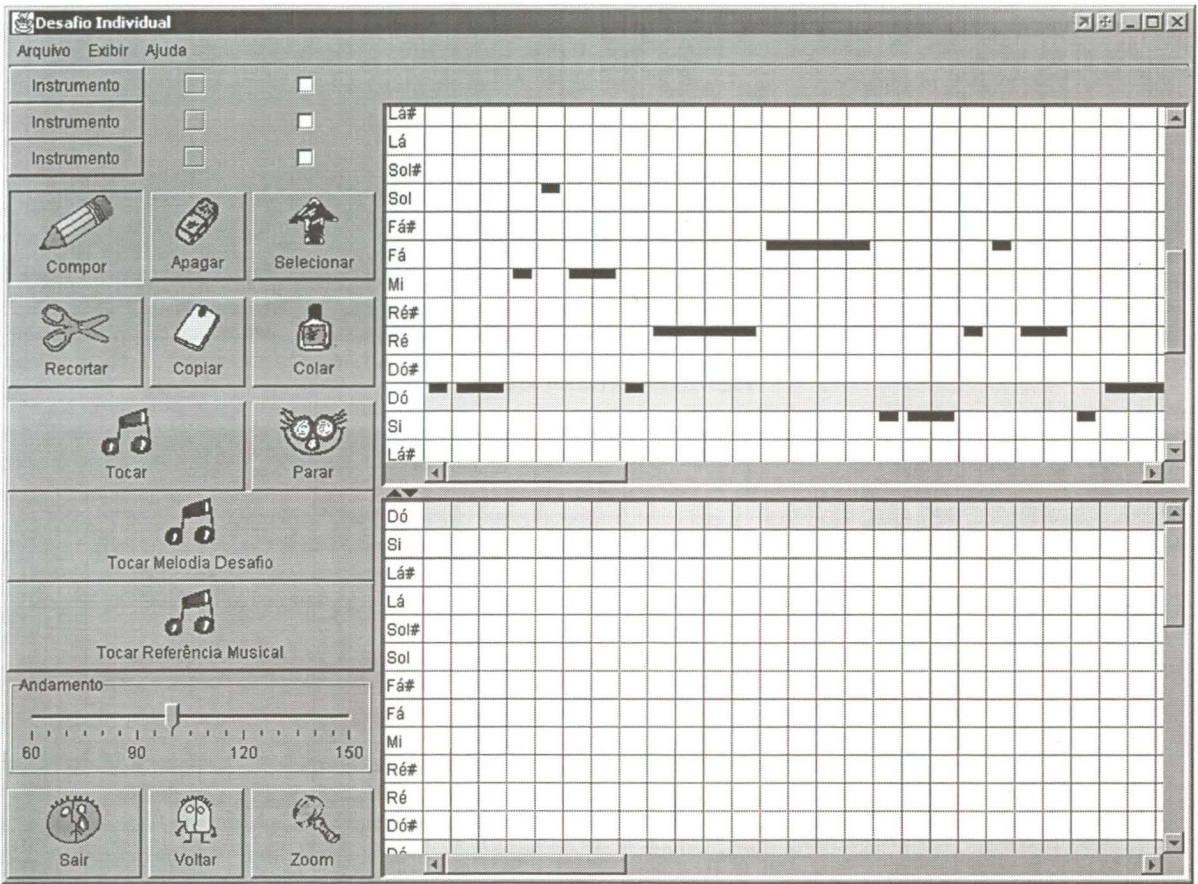
Figure 3: Individual Challenge Mode

3.3 Individual Challenge Mode

In this mode an individual user will work on a challenge or an exercise previously prepared by the teacher. A challenge can be a simple compositional suggestion or an exercise that will help the user discover a musical characteristic or feature.

Figure 3. shows the individual challenge mode screen. The grid on the right side of the screen is divided in two parts; the top part shows a melody prepared by the teacher, the bottom part is used by the student to compose a melody and find a solution to the proposed challenge. In this case the teacher prepared the first phrase of a famous Brazilian popular song. The student's challenge is to try to compose the complete song in the bottom part of the screen. The tool bar contains extra tools like 'Play the challenge melody' and 'Play the musical reference', which can be used to play the melody prepared by the teacher and play a musical reference that the teacher attached to the challenge. The 'musical reference' is a hint the teacher gives to the student; it is a MIDI format file that the teacher may attach to the challenge. The Help menu includes a special command that displays a help message describing the specific challenge.

The challenge is completely parameterized so that teachers can prepare them by simply editing a text document and including special commands to define the help message, the challenge melody file, the musical reference file and any restriction on the instruments section allowed in the specific challenge.

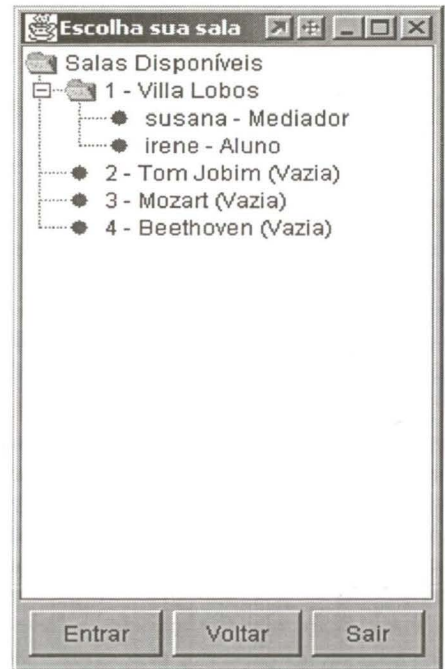### 3.4 Collaborative Composition Mode

Figure 4: Available Classrooms

Using a collaborative composition mode, users interact with each other and with a teacher in virtual environments, and compose together a melody. The execution of the software and the user interface is the

same in both local (LAN) or wide (WAN) networks. The only difference between the two is the connection to the server node.

The collaborative environments are implemented as virtual classrooms, which contain six virtual chairs each, numbered from zero to five. Chair number zero is a chair reserved to a teacher. Students can occupy chairs one to five.

After choosing to work in a collaborative environment, the user must choose which virtual classroom to enter as shown in figure 4. The software lists the available classrooms, the participants' nicknames and status.

In collaborative environments special issues must be defined and implemented so as to organize the collaboration: coordination is treated when different users roles and privileges are defined; collaborative tools allow interaction between users; conflicts between users must be supported.

In the musical composition software, we have defined four different roles or statuses, which are: teacher, mediator, student and observer. A teacher enters a classroom and automatically occupies chair number zero. Only one teacher may be present in each room. The first student that enters the classroom is the mediator and occupies chair number one. The following students enter the room as observers and must interact with the teacher or the mediator to obtain an authorization to occupy a chair. Observers may only visualize the groups' collaborative work and interact with others using the chat area of the screen. Teacher, mediator and students occupying chairs may actively participate in the virtual space choosing an instrument and composing a melody.

Figure 5 shows the user's interface in a Collaborative Composition environment. The tool bar lists the six chairs in the classroom, the nickname of the participants occupying the chair, the participant's instruments and the instruments' color.
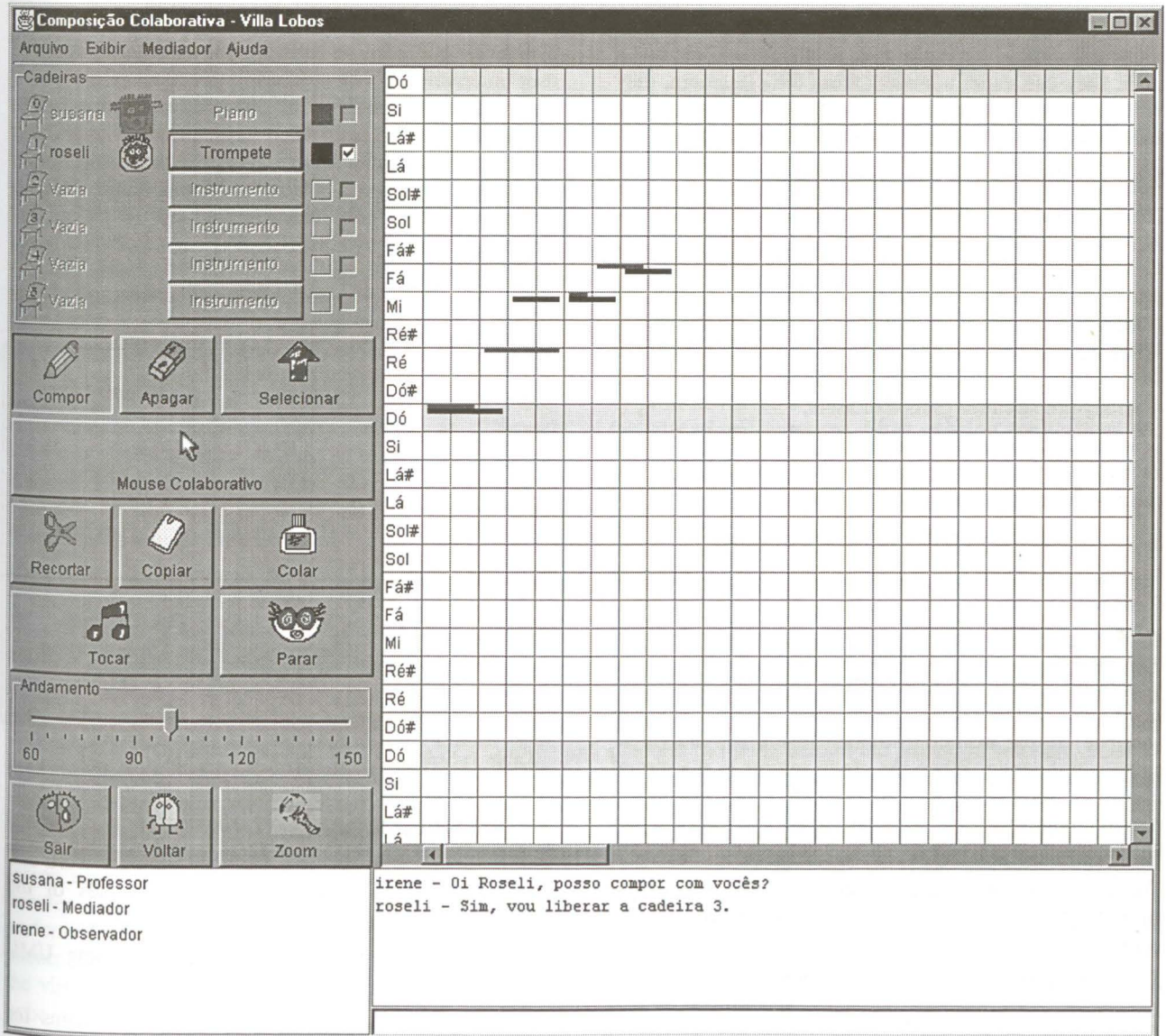

Figure 5: Collaborative Composition Mode

A participant (teacher, mediator or student) occupying a chair may choose an instrument and use the grid area to compose and edit this instrument. Each participant controls his/her instrument. The list of people in the classroom and their statuses are listed in the bottom left corner of the screen. Participants and observers may use the chat area in the bottom right corner of the screen to communicate with each other.

The software synchronizes the users screens so that everybody in the room, participants and observers, visualizes the composition on the grid, the chair list, the list of people in the room and the chat area.

A collaborative mouse has been added to the tool bar. There is only one collaborative mouse available in each classroom. When a participant picks it up, or activates, the collaborative mouse, it is disabled on the screen of the other participants until the participant holding the mouse frees it. The collaborative mouse is used to select and point to part of the grid area, which is transmitted to all the participants.

Teachers and mediators have extra menus and commands: they can authorize a student to occupy a chair, they can expel a student from the classroom, they can transfer the mediator role to another student, and the teacher can also disable the mediator's commands.

3.5 Collaborative Challenge Mode

The collaborative challenge mode is a mixture of the individual challenge mode described in section 3.3 and the collaborative composition mode described in section 3.4. In a collaborative challenge environment users enter a virtual classroom as described in section 3.4 above and collaborate to solve a collaborative challenge predefined by a teacher. Collaborative challenges are challenges specially prepared for groups of users.

Teachers and mediators have a special command in their menus with which they determine which challenge the classroom participants will try to solve.

3.6 On-line and Off-line Collaboration

On-line collaboration is possible when users enter virtual classrooms and collaborate to make a composition or to solve a challenge. During on-line collaboration, users may decide to continue working separately and return later to the virtual classroom. In this case each participant saves the collaborative composition locally and can continue editing his/her instrument using the individual composition mode. When the group returns to the virtual classroom, the teacher or mediator can open a previously started composition and each participant can send the part he/she prepared individually.

The music composition software gives full support to such collaboration, which can be considered off-line collaboration.

4 TECHNOLOGICAL INFRASTRUCTURE

The musical composition software is developed in Java and is implemented as a basic Client-Server architecture. The reason we chose Java is because its pre-compiled bytecodes are highly portable being able to run on any computer with a Java Virtual Machine. Also, Java version 1.3 or later includes the JavaSound package we use to reproduce sounds, notes and musical instruments on the computer. We also used the Java Sockets for communication between remote objects.

According to [Suthers01] different CSCL architectures depend on the coupling level between the users' activities. The musical composition software presented here can be considered a *relaxed WYSIWIS* (What You See is What I See) system, since the virtual classroom participants' work on the same information (composition) but each user can visualize a different part of the information.

Considering the software modeling standard MVC (Model, Visualization, Controller), the music composition software architecture can be defined as a hybrid-architecture according to [Suthers01], since the server and the clients keep a copy of the Model being worked on by the users (in our case the composition) and the clients execute the Visualization and the Controller.

The music composition software allows different types of user interactions: synchronous interaction (same place, same time), asynchronous interaction (same place different times), distributed synchronous interaction (different place, same time) and distributed asynchronous interaction (different place, different time). These interactions have been characterized by the time-space taxonomy defined by Ellis [Ellis91] and are shown in the table below.

	Same time	Different time
Same Place	Virtual Classroom (LAN)	Off-line Collaboration (LAN)
Different Place	Virtual Classroom (WAN)	Off-line Collaboration (WAN)

Table 1: Software user interactions according to [Ellis91]

5 METHODOLOGIES

The presented software is a multi disciplinary work and was conceived and specified by professionals of the technology area and music education area.

The software was analyzed and modeled using UML (Unified Modeling Language).

According to [Druin99], when developing systems for children, it is very important to involve some children in the software development process, since they are the

future users. We have made a study case with future teenage users in the age range of 11 to 14 asking them to verbalize ideas and objects that might represent the tools we planned to implement. This helped us identify and design the user interface and specially the tool bar and buttons.

6 TESTS AND PRELIMINARY RESULTS

Several tests have been conducted in a Local Area Network as well as in a Wide Area Network in order to determine the system performance and efficiency. In a Local Area Network, the test has been conducted on a LAN in its regular traffic conditions with other applications running at the same time.

The software proved to be very efficient and it is perfectly possible to work connected to a LAN in online virtual collaborative environments. We have made some time measurements to check how much time it takes to update the clients' screens. The transmission time of a change in a client, sent through the server takes in average 30 ms to reach and update the other clients.

We have also conducted a test with five teenagers in the age range of 11 to 14, with each teenager working on a workstation and interconnected through a LAN. We suggested the teenagers interact with the software using the individual modes first, and then the collaborative composition mode. We filmed and taped the teenagers during the test and interviewed them afterwards. During the interview the participants mentioned they very much enjoyed 'playing with music' and listening to the result of each change in the grid. Also, the fact that each instrument is automatically associated to a color, made clear that changing the instrument will change the melody color and will change the resulting sound. We have programmed every instrument section as a basic color and every instrument in a section as different shades of the basic color. We asked them to identify the difficulties they had and suggest changes do be made. These suggestions were recorded and will be considered when implementing future features.

Initially, the RMI (Remote Method Invocation) was used to communicate between remote objects. We performed some tests on a WAN, which proved to be acceptable but not fully efficient. We executed the server program on a computer with a 256 kbps download connection and a 128 kbps upload connection. The update average transmission time was 700 ms. Also, some clients with firewalls or NAT had some difficulty in interacting in the virtual collaborative spaces. We reprogrammed the communication methods between the clients and the server, switching from RMI to sockets, so that client and server use a bi-directional communication channel to transfer information from one another. Tests were performed after the change to sockets and proved that clients with firewalls had no difficulty in interacting in the virtual collaborative spaces and the software proved to be very efficient.

We plan on making further pedagogical testes with future users in a real classroom connected to a LAN and in a virtual classroom connected to a WAN. These tests will help us define a methodology, so that we can properly orient teachers that wish to use the software with their students.

The testes we have performed helped us identify the hardware and software minimum requirements which are: Pentium II 233 MHz, 64 MBytes RAM, 50 MBytes free disk space, a sound card, JRE (Java Runtime Environment) version 1.3 or higher, a network card (for LAN environment collaboration) and an Internet connection (for WAN environment collaboration).

Tests in a LAN showed that the program is perfectly functional and can be used in its actual stage of development.

Tests conducted in a WAN showed that the usability of the virtual environments at a distance depends on the connection speed of the user. Therefore, the possibility to work *off-line* is a very important feature of the program.

We plan on developing a tool that transforms the simplified notation used in the program to a staff with conventional notes, and later a composition editor for conventional notation, so that the user can switch from one to the other.

We also plan on using alternative interaction interfaces, like a MIDI keyboard, the regular alphanumeric keyboard, or yet another equipment we will develop especially for the software program.

7 CONCLUSION

We have presented a virtual collaborative environment developed for music education, which is an innovation from the computer supported musical composition point of view. Most composition applications are widely used by professionals but not by children or teenagers, and not for educational purposes. Most existing applications are for individual work and do not include the possibilities of collaborative environments.

In a virtual environment, groups of students actually work together on the same composition, where each student is responsible for his/her part of the composition and can give his/her opinion about the colleagues' part.

From the pedagogical point of view, the composition activities are important ways to relate to music and to develop the students' musical knowledge. However, this kind of activity is rarely used in regular Brazilian schools. With the help of the presented software, musical composition can become a more accessible and a less mysterious activity, for both students and teachers, and it is therefore a precious teaching and learning tool.

Musical instruments are not usually available in schools and especially in public schools, so there is no development of musical activities. Nevertheless most schools already have computer labs that can be used to develop these activities using the computer instead of real musical instruments.

The musical composition software offers virtual collaborative environments that can either be used for students group work in a LAN but also for group work of

students and teachers connected by a WAN. This feature can be used to create interaction environments for students and teachers at a distance, and can be a way to exchange experiences between remote located schools as well as users.

8 ACKNOWLEDGEMENTS

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