



Virtual Music School User Requirements Document



The VEMUS project is partially supported by the European Community under the Information Society Technologies (IST) priority of the 6th Framework Programme for R&D.



V E M U S
Virtual European Music School



VEMUS Project

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Executive Summary

The aim of the users' requirements document is a) to present users' requirements elicitation methodology and b) to describe and to categorise the users' requirements for the VEMUS system. As the VEMUS project exploits the work performed in IMUTUS project (Schoonderwaldt, Hansen and Askenfelt, 2004). IMUTUS system was considered as an initial system concept for the VEMUS project, which serves as a preliminary and provisional concept of reference useful before users' consultation. IMUTUS system, as well as systems sharing similar philosophy and pedagogical objectives, was exposed to users' consultation, in order to ignite comments, criticisms, expectations and visions for VEMUS. However, by "project" definition, VEMUS adopts a greater vision than IMUTUS. VEMUS aims at developing an open, highly interactive, and networked multilingual music tuition framework for instruments such as the trumpet, the flute, the clarinet and the recorder. The system will address students of beginning to intermediate level in different learning settings: Self-practicing, classroom and distance learning. The ingredients of VEMUS' greater vision are crucial in the requirements elicitation phase. Sketches of the VEMUS envisioned interface, descriptions and scenarios of use were also exposed to users' consultation during the user requirements elicitation phase.

In order to envision the VEMUS functions the consortium had to look at current practices of music teaching and examine how we can best support them or even allow for the system to simulate aspects of it for the benefit of the student. Teachers of music, who became familiar with the VEMUS initial system concept and wider vision, are consulted as an important type of users.

Data collection for the user requirements took place during **workshops and interviews**. Such "in-context" conditions are created by allowing the teachers and the students to interact with software applications that may provide similar features but they do not include the overall innovative approach of VEMUS. thirty five experienced music teachers (of clarinet, trumpet, saxophone, flute and recorder) from Greece, Sweden and Romania participated to the 7 requirements workshops performed in a period of between November 2005 and March 2006. Additionally about 40 music teachers have been interviewed in Greece, Lithuania and Estonia. In cases where it was considered important for the consortium to have additional input **web surveys** were used in order to collect more data (e.g. in the case of the performance evaluation, which is maybe the most important and critical aspect of VEMUS system interaction with the user, an extended web survey was additionally launched).

The analysis of collected data resulted in the definition of a **detailed requirements list** and from this to a **set of use cases** that illustrated the VEMUS context of use bearing in mind the elicited user requirements.

The picture of user requirements was complemented by information that illustrates the general landscape of music instrument tuition. More specifically this information refers to

i) research on music education, ii) current or past projects, similar to VEMUS or closely related to some of the points to be developed by VEMUS, iii) Online educational resources and iv) existing commercial systems that are similar to VEMUS or that their approach could be of interest to the project.

Overall the analysis of data collected indicates that teachers of wind instruments are interested in:

- Adjusting their teaching to individual student's level and skills
- Planning and adjusting the content (melodies, exercise, order of introducing notes, study procedures, annotation and visualizations) to the students' needs
- Improving the interaction between student and teacher
- Finding appropriate ways of communicating hard-to-teach points to all students
- How their guidance, study practice priorities and assignments in the classroom are reflected in the student's self practice
- The organization, classification, and presentation of music content.

These are the basic identified requirements for a system like VEMUS. The consortium has to take into account these basic needs during the whole process of the system development. Additionally these requirements have to form the basis for the development of the evaluation and usability process to safeguard that the system's developments are covering the identified needs and satisfy the final users.

This document includes 8 main sections. Section 1 gives an indication of current trends in the field that have to be taken into account during the design and the development of the VEMUS system. This section includes also the conclusions of the extended market survey that was realized during the first year of the life cycle of the project. Section 2 describes in detail the procedure of collection and analysis of data acquired from the music teachers who have participated in the workshops and the interviews. In Section 3 the discussions and the conclusions from the four (4) Introductory Workshops are presented in detail. In Section 4 the nine (9) initial scenarios of use that were designed to act as an instrument to capture and provide a common understanding of the functionality and merits of the envisioned system are presented. These initial scenarios of use give a lot of emphasis on the functional specifications of the system and they were prepared from the consortium to support the VEMUS System Requirements process. The scenarios illustrate the use of the three Environments –self-practice, classroom and distance learning, as well as the more specific features. Section 5 describes the second series of workshops that focused on the design of the system (based on the proposed initial scenarios) in order to meet the users needs and requirements. Additionally to the second series of workshops a series of interviews with music teachers from the participating countries was designed and implemented. The process is presented in Section 6. Forty teachers were interviewed on a set of questions drawn from the four introductory workshops, and issues raised in the first version of the User Requirement document and the Consolidated User Feedback document. The aim was to acquire specific answers on issues generated in this first period of user requirements elicitation. In Section 7 the user requirements for the VEMUS system are presented. They are associated with user input and backed by published research. Based on the consolidation of user input five major categories of pedagogical issues and aspects

are identified: teaching practices, studying procedures, performance evaluation, visualisations and educational content. Additionally a list of user requirements summary for each one of the five categories is extracted, based on analysis of the workshops and interviews transcripts. Finally, Section 8 describes the main VEMUS use cases. These are based on the extracted requirements and this is signposted in the last paragraph of every use case presentation. Furthermore, it is also attempted to show how each of these cases may be linked together.



1. Current Trends in Music Technology

1.1. Literature Review

Music technology has become a recognised subject area in its own right. However in discussing future scenarios it is important to acknowledge the relevance of music in children and young people's lives, and the musical cultures and communities that emerge in and around clubs, rehearsal spaces, homes, arts centres, conservatories and schools. This session presents an indication of current trends in the field that have to be taken into account during the design and the development of the VEMUS system.

Despite several survey reports on the application of music technologies within schools and conservatories (Dillon et al 2001; Mills and Murray 2000; Ofsted 2002a, 2002b, 2004; Pitts and Kwami 2002), **little detailed work has been carried out on how they actually influence learners' processes** (creative, collaborative or individual) **and musical understandings**. The nature of music instruction embodies an ongoing alternation between teacher instructions, feedback, and student performance trials, and this alternation of teacher and student activity has been studied extensively in recent years (Duke & Henninger, 1998; Goolsby, 1997; Hendel, 1995). Much of this process is conducted verbally; however, annotation and visual representations may also be employed (Nesi et al., 2004). The scope of understanding current practices is to seek for effective practices. Pitts, Davidson & Mc Pherson (2000) claim that "Too often, instrumental lessons fall into a similar pattern every week, so that children lose the sense of interest and excitement of the first few weeks". The development of expertise is strongly related with effective strategy use (Hallam, 2001). The predominance of "technique" and "command-style" teaching strategies (Young, Burwell & Pickup, 2003) described in the "master-apprentice" model may not be appropriate for all areas of study. Research that has been carried out across various primary (Mellor, 2001), secondary (Dillon, 2003, 2004; Folkestad, Hargreaves and Lindström 1998; Seddon and O'Neill 2001) and non-formal (Dillon, 2004) learning settings has focused on different technologies and research questions, and so although our knowledge is steadily growing, work in the field has tended to be sporadic and centred on individual researchers' interests and orientations.

For example, studies have shown that **teaching practices tend to focus around particular hardware and sequencing or notation packages**. Consequently learners' experiences are limited and **the full potential of music technologies has not yet been fully explored in schools and conservatories**. As noted in the recent Ofsted report:

"Most music departments base the majority of work in music technology on one piece of software – typically either sequencing or score-writing. This can result in pupils gaining limited experience in the wide-ranging applications of ICT in music. A minority of

departments make good use of a range of software, including audio editing programs and CD-Roms to develop skills such as aural perception and understanding of musical form and history.” (Ofsted 2004, p4)

Innovation in music teaching with technology tends to be driven by individual teachers who are passionate and interested in this area. Similar to the use of ICT in art (eg refer to Arts Council of England, ‘Keys to Imagination ICT in Art Education’, 2003), exemplary music technology practices are unusual and sometimes little known outside the school or department context.

This is not to take away from the successes of music technology in schools and conservatories. Various surveys (Mills and Murray 2000; Ofsted 2004) have reported that teachers find music technology opens up the curriculum and allows all abilities access to music. **In addition technology provides teachers with an additional toolkit through which they can engage young people in the sophisticated process of composition** (e.g. through sequencing packages such as Cubase and sampling software such as eJay) as well as **enhancing music appreciation** (eg through the use of CD-Roms, web etc). Teachers have also cited more functional benefits **of using computers for storing, saving and retrieving music, which they find useful to track pupils’ progress** (Dillon forthcoming; Dillon et al 2001; Mills and Murray 2000; Ofsted 2004; Pitts and Kwami 2002).

On a negative note, some of the most commonly cited problems with using ICT in music are **lack of funds, inadequate training and lack of technical support**, particularly when computers crash etc (Dillon forthcoming; Dillon et al 2001; Mills and Murray 2000; Ofsted 2004; Pitts and Kwami 2002).

From the VEMUS perspective and aiming to build upon the very successful IMUTUS system that was mainly developed to support music learning at home, it is necessary to not only share examples of exemplary school practices but also discuss how schools can become sites of musical innovation, which embody both traditional and contemporary approaches to music, by providing rich musical experiences for all ages and abilities.

Research in cultural and popular music studies also offers valuable insights into the practices that have emerged from, through and around the use of various audio and sound technologies (Cox and Warner 2004; Troop 2004), from studio equipment (Hebdige, 1993), to Walkmans (du Gay, Hall, James, Mackay and Negus, 1997), to the Internet and iPods (Quantum, 2004; Toynbee, 2003). This body of work demonstrates the influence of technologies as music-making tools and how individuals use and repurpose them for their own musical ends.

However since the innovation of cassette tapes and home recording devices in the 1970s, the music industry has continually tried to control and legitimise the practices of music production, copying and distribution (Chestermann and Lipman, 1988; Plumleigh, 1990). The current proliferation of high-speed, wireless networks and peer-to-peer file sharing has changed and challenged the global music market (Fessenden, 2002; Toynbee, 2001). Despite the music industry’s continual clampdown on peer-to-peer networks and file sharing, independent studies (Goetz, 2004; Oberholzer and Strumpf, 2004) show that their

“cries” of sale loss are in some cases unsubstantiated.

In sum, today we live in a ‘download’ culture; how we create, share and listen to music is directly influenced by our increasingly networked world.

In relation to our discussion, it’s essential we discuss the relevance of peer-to-peer networks, file sharing and mobile music devices on contemporary music making and sharing. It is still open as to the kinds of interactions and practices that will emerge from the everyday use of connected online music devices. In considering future visions of music, the possibilities and implications of these devices have to be discussed and taken into account during the VEMUS system’s developments.

There is a significant amount of research and literature concerning music education that is of evident interest for computer education systems, in particular (i) research focused on instrumental teaching and learning practices (Jorgensen, 2003; McPherson, G., 2005; Pitts et al, 2000;) (ii) studies concerning music assessment and teachers’ feedback (Pitts, 2000; Reynolds et al, 2004;), (iii): research on performance skills and musical development (Lindström et al, 2003; Bresin, 2005). Closely related to VEMUS’ rationale on providing an effective self-practice environment is the literature review on performance skills. Researchers that examine performance skills believe that performance level is dependent on three time variables, namely initial starting age – current amount of practice and accumulated practice time (Sloboda, 1996, O’Neil, 1997). There are two predominant models of practicing, the one developed by Hallam (1997) that presents a cognitive model of learning process depending on learner’s characteristics and learning environment and Jorgensen’s model on practicing in context (1997) which develops the notion of self-teaching and is mostly used to advanced instrumental learners: planning and preparation of practice, execution of practice and observation and evaluation of practice. What literature review reveals is a lack of sufficient teaching on how students should practice (Jorgensen, 2000). Many issues related to literature review, to its constraints and concerns, are furthermore elaborated in the next sections of this document, addressing specific areas of research.

There have been numerous attempts to use computers in music education. These applications use different and sometimes contrasting approaches. The field is highly interdisciplinary, involving substantial contributions from the fields of music, social psychology, anthropology, artificial intelligence, cognitive psychology, human computer interaction, computer science and many other fields. This section attempts to consider some computer applications that teach musical performance skills. Music education applications use a range of techniques from Computer Assisted Instruction (CAI) to Intelligent Tutoring Systems (ITS) or Artificial Intelligence (AI) in conjunction with different instructional strategies. Contrasting to ITS, CAI systems present a limited teaching strategy as they have no explicit representation of the knowledge to be taught or ability to reason about it and cannot differentiate between different students (Brandao et al, 2007). An ITS application basically consists of an instructional environment containing three kinds of knowledge: a) *expert knowledge* of the domain being taught well enough to be able to draw inferences and solve problems in that specific domain, b) *student diagnostic knowledge*, that is being able to understand the student’s approach to the knowledge and detect and correct possible misconceptions and c) *curricular knowledge*, being able to reduce

the difference between the expert and the student knowledge by means of specific pedagogical approaches (Burns and Capps, 1988).

Music is an open-ended domain where there are in general no clear goals, no criteria for testing correct answers and no comprehensive set of well-defined methods. Music composition and expressive performance are replete with problem seeking (when for example the learner should perform a musical piece “with feeling”). A classification that may be proven particularly meaningful in relation to educational software design is that of behaviourist versus cognitive approach. **Behaviourist or programmed learning** which forms the basis for CAI is based on responses to some questions that should be given by the student (in accordance to Skinner’s work on *operant conditioning*). Historically, the first use of computers in teaching music was usually associated with this theory (a representative example of this kind of system is the GUIDO ear-training system). On the other hand, **cognitive learning** may be discerned on instructional strategies such as socratic dialogue (discovery-learning strategy), coaching/monitoring and exploratory. The possibilities of multimedia presentation and hypermedia have transformed music education software, giving emphasis to cognitive learning. Roughly speaking, the history of AI in education can be divided into two periods, the first period from about 1970 to 1987 and the “modern” period from about 1987 to the present day. For simple musical activities such as teaching performance skills, the programmed learning approach has proved to be appropriate as most of the time these activities involve only comparing the student’s answer with pre-stored templates.

1.2. Market & Research Environment

This section attempt to examine the recent developments on the field of computer music education. Relevant to VEMUS system software are examined and categorised as:

- Current or past projects, similar to VEMUS or closely related to some of the points to be developed by VEMUS.
- Existing commercial systems, provided that they are similar to VEMUS or that their approach could be of interest to the project.
- Online educational resources.

At the end of the section Learning Management platforms are also examined.

Research projects

This section examines a number of educational software applications that belong to ITS classification and specifically address the development of performance skills. Some of the features that VEMUS incorporates are also met in these applications but none of the software under examination does incorporate all the innovative features that VEMUS develops (see also Table 1). The features addressed to VEMUS and these applications may be summed as:

- a) adaptation to the needs of each student
- b) provision of an intelligent off line feedback on students’ performances

- c) provision of a real time feedback on student's performances
- d) error-diagnostic explanation of student's performances
- e) score-following of student's performance
- f) provision of accompanying music that can start from any position in the score
- g) use of extensive multimedia to enhance the interactivity between the learner and the system, such as the fingering viewer
- h) distance learning environment that form a content repository for storing student's performances, for retrieving exercises and repertoire and for uploading and downloading teachers' comments, annotations and emoticons

One of VEMUS benchmarks is the provision of highly sophisticated **visual feedback**. Although not very common, computer applications are considered to provide visual feedback, for analysis, for educational purpose or both, in deferred or in real-time, on aspects of performance such as intonation, vibrato shape, tuning, dynamics and timbre. Some applications, such as Tartini (<http://www.tartini.net>), are designed for self-practicing but without adopting any educational approach. Other applications aim to novice learners and adopt an instructional approach. For example, Piano Tutor Project is an ITS for teaching the psycho-motor skills of piano playing. It relies on giving tutorial feedback on the accuracy of the novice's piano performances and the system is supported by interactive video-disks of a human teacher and a matcher for comparing the student's performance with pre-stored expert performances. The Feel-ME project furthermore develops the so called "cognitive feedback" that is addressed to advanced instrumental learners and define the nature of musical expressivity. In a number of the examined applications (i.e. Smart Music) the feedback is not designed with a pedagogical approach as a) it does not guide the student to improve his/her mistakes b) it does not provide positive feedback on the good aspects of student's performance and c) it does not prioritize the remarks during the performance evaluation. VEMUS, however, by using (i) audio and text annotations, (ii) emoticons and (iii) visualisations, attempts to add an educationally meaningful dimension to the provision of feedback to student's performances. The educational approach of VEMUS is furthermore enhanced by the concept of **VEMUS Music School House**, an innovative feature of the system that brings a solution on how to use priority lists of skills and adapt them to each student's level and personal character.

Accompanying music, that is recorded reference performances, recorded piano accompaniment or recorded examples of a specific style or aspect such as "swing", "vibrato" et al, is encountered in many applications. This accompanying music may vary, though, in terms of adaptability to student's performance and genre (digital or live performances).

VEMUS is furthermore the only music software that addresses three different learning environments, self-practice – classroom teaching – distance learning. Classroom teaching in particular demands specific **collaborative features**, such as the use of the music score as a sophisticated *communication channel* between the teacher and the students and the performance monitoring. The term *groupware*, first introduced by Johnson-Lenz, is often used to describe a computer-based system that supports groups of people engaged in a common task (or goal) and that provide an interface to a shared environment.

Table 1: Comparison of music software applications with VEMUS proposed functions. VEMUS presents the following innovative features: annotations, emoticons, VEMUS Music School House

Presented music software applications	Proposed VEMUS Functions												
	Annotations	Emoticons	Off-Line Feedback	Real Time Feedback	Error-diagnostic explanation	Accompanying music	Multimedia environment	metronome	Collaborative features for group teaching	Video Recording	Score-following	Adaptation to each student's needs	Material from content repository
IMUTUS			•			•	•	•		•	•		
Piano Tutor			•	•		•		•			•	•	•
Virtual Music Teacher			•	•	•	•							
I-Maestro							•		•	•			•
Feel-ME			•	•		•		•			•		
Exploration and training...				•		•							•
VOXed				•									•
Sing & See				•									•
SmartMusic			•	•		•		•			•		
In the Chair				•	•		•			•			

Table 1 clearly demonstrates two issues:

- VEMUS is the only music software application that combines all the above presented features.
- The following features are innovative and are met only in VEMUS: annotations, emoticons, VEMUS Music School House.

IMUTUS

<http://www.exodus.gr/imutus/>

The IMUTUS Project is the predecessor of VEMUS. It was funded by The European Commission under the Information Society Technologies (IST) framework. The project started on May 2002 and officially ended on February 2005. The main goal of IMUTUS is to provide an **interactive music tuition multimedia system** for training users on traditional instruments with no MIDI (Musical Instrument Digital Interface) output. The selected instrument is the **recorder**. The system is based on audio / optical recognition,

multimedia, virtual reality and audio-to-MIDI transformation technologies. Through an innovative user interface for music tuition the student is able **to practice on his own**, and have electronic guidance, whenever he requires it, through Internet communicating with a teacher group, mandated with the responsibility to either provide feedback to the student or participate in a distance learning modality. The trial courses are organised considering several pedagogical aspects.

Piano Tutor

The Piano Tutor was developed in 1990 at the Carnegie Mellon University. The philosophy behind the project was to **enhance piano teaching by using it as an assistant during practicing, emulating the teaching process**. The performance analysis is based on a real-time polyphonic score following method, enabling automatic page turning and adaptation to tempo and score position (accompaniment). The information of the score follower is used by an expert system to generate the response to the student, focusing on high-level errors. The system includes a database with exercises. The lesson selection is based on learned skills, which form the prerequisites for new exercises.

For more information:

A Computer-Based Multi-Media Tutor for Beginning Piano Students Interface
Dannenberg, Sanchez, Joseph, Capell, Joseph, Saul
Journal of New Music Research, 19(2-3), 1990, pp. 155-173.

Results from the Piano Tutor Project

Dannenberg, Sanchez, Joseph, Joseph, Saul, and Capell,
Proceedings of the Fourth Biennial Arts and Technology Symposium, Connecticut College, (March 1993), pp. 143-150.

Virtual Music Teacher

The Virtual Music Teacher project was developed in 2003. The goal of the project was to define how we can teach music with a software. It doesn't include any musical theory basis, which can be found in any music book, but realizes an "artistical diagnostic" on played music, as would do a real teacher: with a score as reference, **detect errors** on played music, and find ways to avoid them. Typical errors are for example wrong notes, rhythm errors, tempo errors, and interpretation errors. That implies good definitions of errors and diagnostic rules, which requires to develop a way to acquire and to model played music, output definition, etc.

For more information:

Inquiry for Music Teachers
<http://gmwork.free.fr/Vmt/inquiry.html>
Professeur de Musique Virtuel
Gilles Mathieu
http://gmwork.free.fr/Vmt/vmt_french.pdf
Virtual Music Teacher Project
Gilles Mathieu
http://gmwork.free.fr/Vmt/vmt_general_doc.pdf

I-Maestro

<http://www.i-maestro.org/>

I-Maestro stands for “Interactive Multimedia Environment for technology enhanced music education and creative collaborative composition and performance”. The project is supported by the European Commission under the IST Sixth Framework Programme to develop interactive multimedia environment for technology enhanced music education. The project aims to explore novel solutions for music training in both theory and performance, building on recent innovations resulted from the development of computer and information technologies, by exploiting new pedagogical paradigms with cooperative and interactive self-learning environment, gesture interface, and augmented instruments, with computer-assisted tuition in classrooms to offer technology-enhanced environment for ear- and practical-training, creativity-, analysis-, and theory-training, ensemble playing, composition, et al. Many aspects of **music performance of string instruments** are examined such as expressivity, interactivity, gesture controllability and cooperative-work among participants. **E-learning courses** are also incorporated in order to improve accessibility to the musical knowledge.

The project has started in fall 2005 and results are thus not available.

Feel-ME - Feedback-learning of Musical Expressivity

<http://www.psyk.uu.se/hemsidor/musicpsy/index.html>

The aims of this project is to (a) define the nature of **musical expressivity**, and (b) develop new methods for teaching expressivity based on recent advances in musical science, psychology, technology, and music acoustics. A new and empirically-based approach to learning expressivity called **Cognitive Feedback** is being developed and implemented in user-friendly software that is evaluated in close collaboration with musical conservatories. The project involves an interdisciplinary collaboration among psychologists, technicians, music teachers, and musicians. Topics addressed by the project are computational modelling of different components of musical expressivity, models of expression of emotions in music composition and performance, cross-modal comparison of acoustic cues in emotional speech and music, automatic real-time extraction of acoustic cues from music performances, et al.

Exploration and training of music performance skills by means of adaptive monitoring and visual feedback

<http://www.stw.nl/Projecten/N/nnn/nnn6301.htm>

This project is designed for advanced instrumental players and focus on these important aspects of music performance that are not prescribed in the score, such as the amount of motor control needed for achieving the chosen expressive timing, dynamics, intonation, articulation, et al. In this project a system will be developed that **monitors a student during practice** and provides **feedback** on the success of imitation in an integrated visual way. It allows teachers to build libraries of exercises in the form of recorded audio fragments, examples and counter examples of a specific style or aspect (e.g. “swing”, agogic accent, vibrato) instead of explicit instructions. From the sound fragments (examples and counter examples) the features are deduced that are relevant to explore and learn, and these are extracted in real time while the student is practicing. Feedback is provided as a mapping from these relevant features to **parameters of a visual form** (shape, texture, orientation,

color, position etc.). This helps in exploring through the space of possible performances. How the method helps in learning to control the instrument will be evaluated in several experiments. The best design choices will be put in a prototype for music students that (depending on available technology) may be accessible globally via the Internet or on computer game consoles.

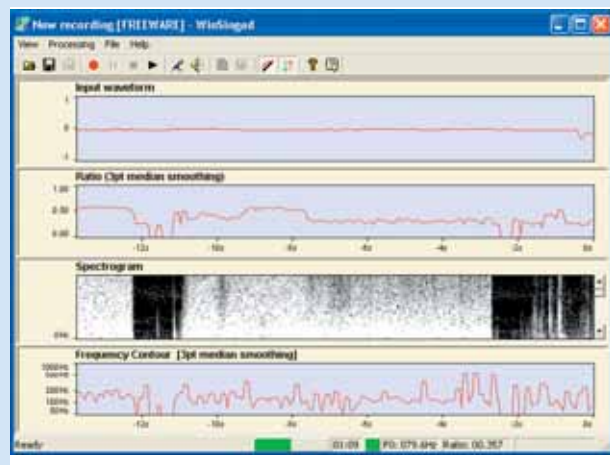
The project is at a proposal stage.

VOXed

<http://www.voxed.org/>

The overall aim of the “VOXed” project is to investigate the usefulness of **real-time visual feedback technology in the singing studio**. This is achieved by:

- Gaining input from singing voice professionals on the nature of useful pedagogical data.
- Working for an extended period in a singing studio, gathering longitudinal data from a number of perspectives.
- Establishing the parameters that might be used for visual feedback
- Reporting outcomes to the singing voice professional community and other researchers.
- Considering the wider application of such systems for encouraging healthy voice use.



The technology base of the VOXed project is a freeware application named WinSingad. It analyzes sound information from input devices such as a microphone connected to your computer and presents a variety of views onto the resulting data (**frequency, spectrogram, spectrum** etc). Recorded sessions can be saved to standard wave files and reloaded at a later date for further analysis. The product has evolved over several years incorporating analysis techniques from a series of projects and has most recently been used to assess the viability of using such technology in the context of professional singing lessons.

For more information:

Technology For Real-Time Visual Feedback In Singing Lessons.

David M. Howard

Research Studies in Music Education, Number 24, 2005, pp.40-57

Real-time feedback in the singing studio: an innovatory action-research project using new voice technology

Graham F. Welch, David M. Howard, Evangelos Himonides and Jude Brereton

Music Education Research Vol. 7, No. 2, July 2005, pp. 225-249

winsingad

<http://www.sarand.com/prd/winsingad/winsingad.html>

Market Environment

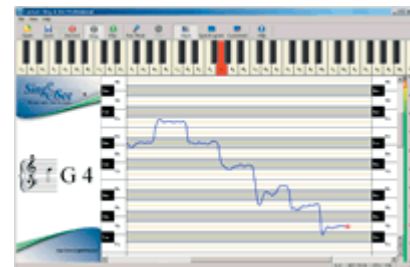
Existing commercial software for music practice

Two commercial software are close to the VEMUS project objectives: SmartMusic and In The Chair. Although restricted to the singing voice, another commercial software is considered - Sing & See - for its graphic feedback features.

Sing & See

<http://singandsee.com/>

Sing & See is a tool that provides **real-time feedback on the voice**. It helps while practicing, to check up on pitch, or just to give something to focus on during warm up. This direct visual feedback gives the singers visual cues (such as the spectrogram) that can break through auditory perceptual barriers, enhances the spoken feedback that teachers give their students and allows singers to see patterns in their voices that they might otherwise miss out on hearing. It is designed to complement teachers' lessons but it is also intended to be used as part of **self-directed learning**.



For teachers, Sing & See is designed to complement individual teaching style. It provides a variety of feedback displays that can be used to focus on particular aspects of the students' voice. It can also be used to illustrate aspects of a students' vocal production, as part of a normal lesson.

The software is delivered under the form of a student version, a professional version and a teacher pack.

SmartMusic

<http://www.smartmusic.com/>

SmartMusic is a complete **music practice system** for woodwind, brass, string, and vocal musicians. It is intended to a wide range of skills level: from first year beginner to professional musician.

The pedagogical approach is mainly based on **accompaniment to improve performance**. An exclusive **Intelligent Accompaniment®** system, using piano sound, can actually follow the student spontaneous tempo changes like a good human accompanist. While learning a piece, you can turn off Intelligent Accompaniment and follow the music's original tempo or



the tempo of your choice. SmartMusic offers a great variety of practicing modes: exercises, rhythmic exercises, score based training, playing by ear, all of them automatically accompanied. It includes performance assessment and provides results under the form of graphic colored notes indicating correct and wrong performed notes.

By using SmartMusic the student may record and save a part or all of his/her performance. However, there is no automatic mapping between the recording and the score. It supports

a great variety of music styles: popular music, jazz repertoire, classical music... Accompaniments can be created in Finale 2005 or 2006. The full features of the system are activated by subscriptions. Home or school subscriptions are proposed.

In The Chair

<http://www.inthechair.com/>

In The Chair is an instrument practice system targeted to classical orchestral music. By using a **multimedia** environment it allows student to **practice together with a professional band or orchestra**, to be placed inside the band, to hear the other musicians around and to watch the video of the conductor and play together with the ensemble.

In the Chair provides immediate **aural or visual feedback** on the performance (on pitch, rhythm, tone and dynamics) and encourages to correct any mistakes. A grade is computed in real-time while correct notes and mistakes are highlighted during the progression of the music. The application is based on a music library that is being constantly updated. The recording facilities and the feedback of student's performances are not particularly sophisticated as the evaluation of the performance at the end of the recording is limited to a grade. As the system is very recent only a free trial version is by now available.



Online educational resources

Distance learning is a flourished domain: research, resources, frameworks, experiments have been developed for over a decade. Restricting the approach to the music domain the main technologies in use are:

- streaming audio and video

- interactive video
- web-based course management systems
- web-based delivery of content

Note that these technologies are not mutually exclusive and may be combined in various ways.

In addition, distance learning systems can provide synchronous and/or asynchronous learning, instructor-led and/or computer-based training:

- Synchronous Learning - Any learning event where interaction happens simultaneously in real-time. This requires that learners attend class at its scheduled time. Could be held in a traditional classroom, or delivered via distributed or e-Learning technologies.
- Asynchronous Learning - Any learning event where interaction is delayed over time. This allows learners to participate according to their schedule, and be geographically separate from the instructor. Could be in the form of a correspondence course or e-learning. Interaction can take use various technologies like threaded discussion.
- Computer Based Training (CBT) - Training or instruction where a computer program provides motivation and feedback in place on a live instructor.
- Instructor-led Training (ILT) - A learning event which is led by an instructor, and either held in a physical location or delivered via a network.

In the following section some known online music educational resources are presented:

MusicWeb - Enabling music schools to bring the classroom to users desktops

<http://musicweb.koncon.nl/>

MusicWeb aims to improve quality of music education, by exploiting multimedia and distributed network technology, of which the potential, also for **distance learning**, has already been demonstrated in previous projects on national levels at the partner institutions. MusicWeb intends to support music education by offering a well-structured learning environment with a strong emphasis on musical relevance. The **modular design** and reusability of tools and materials should appeal to music professionals, teachers and students regardless of their technological background.

The project has been carried out with the support of the European Community through the eLearning Programme.

The Cleveland Institute of Music - Teaching is the focus. Technology is the means.

<http://www.cim.edu/distanceLearning.php>

Distance learning programs connect in real time to teachers and students through high-speed video conferencing technology. Web-based and other multimedia materials augment each **videoconference** connection. Programming is offered in four areas:

- Pure Music, which includes music master classes, courses in music theory and Dalcroze Eurhythmics, early childhood music education, music proficiency for young musicians, and special programs on music history and literature.
- K-12 Interdisciplinary, which includes programs specially designed for science, language arts, and history classes. These programs target specific academic proficiency

skills while enlivening the curriculum with music and musical ideas.

- Professional Development, which provides valuable courses for educators, performers, music administrators and distance learning program administrators.
- Community Service, which provides music resources to hospitals, nursing homes and other community venues.

The distance learning platform also provides online concerts.

The Manhattan School of Music

<http://www.msmnyc.edu/special/distancelearning/>

In 1996, under the pioneering influence of President Marta Istomin and Maestro Pinchas Zukerman, Manhattan School of Music instituted a groundbreaking **distance learning** program devoted to exploring the use of state-of-the-art videoconference technology for music education and performance. Since its inception, the program has connected students, educators, and distinguished artists around the globe for teaching and learning exchanges and currently reaches over 1700 students each year from Albuquerque to New Zealand.



Manhattan School of Music's distance learning program offers a wide selection of educational videoconferences including master classes, private lessons, clinics, workshops, coachings, sectionals, colloquia, educational & community outreach, telementoring, professional development, and humanities exchanges.

Berkleemusic.com

<http://www.berkleemusic.com/>

Berkleemusic.com is the online Extension School of Berklee College of Music. It offers a large catalogue of **courses** targetting producers, guitarists, arrangers, songwriters, business professionals, teachers as well as performers.

Berkleemusic's interactive learning environment uses QuickTime and Flash movies, animated demonstrations, diagrams, sound files and workshops. Pedagogic approach is mainly based on instructional videos and interactive practice activities.

Indiana University Online and Distance Education

<http://www.iu.edu/~iuonline/de/decourses/music.html>

Indiana University offers dozens of online courses with various delivery methods: print/correspondence, Internet, audio/video streaming. The university also develops the Variation2 Digital Music Library Project to support the educational activities:

<http://variations2.indiana.edu/overview.html>

Learning Management platforms for VEMUS

WebCT URL: <http://www.webct.com>

WebCT is one of the leading provider of e-learning solutions to the higher education sector. It offers two main products:

- ‘WebCT Campus Edition’, which is a course management system designed to be implemented across a higher education institution. As well as content delivery and management it includes student performance assessment and tracking and communication tools such as whiteboard, discussion forum and instant chat room.
- ‘WebCT Vista’, which is described as an “enterprise-class e-learning system” - it appears to do the same as Campus Edition, but with a few extra features such as role-based authentication, an SDK to allow application extensions to be built, and additional functionality in the communication tools, allowing ‘cross-course’ communication.

WebCT can provide personalised learning paths for users, as access to objects can be conditioned on a wide range of personal data including achievement, date/time and class code (i.e. there may be many classes taking the same course, with different materials available to different classes). In reality this is seldom used to any great extent due to the high cost of developing learning materials in different styles and setting up courses to use these effectively. Personalization at the level of the individual learner is usually restricted to allowing users to set individual bookmarks and providing a single-sign-on system – i.e. the system knows which courses a user is registered for, and once signed in once all of these courses can be accessed without the need to sign in separately for each one.

There would seem to be a lot more scope for individual personalization than this, as the WebCT system records quite a lot of information on the behaviour of the users (which documents they visit, how long they spend viewing them, test results and grades). At present this information seems to be used solely for the production of reports, but could be used towards providing a truly personalised educational experience without the need for large investments of course designers’ time.

Xtensis

Xtensis claims to be “a revolution in the management and delivery of e-learning” as it is specifically designed to handle LOs and their (IMS and SCORM-compliant) metadata. It is usable ‘out of the box’ as a learning management system, but can be configured to reflect the structure of an organisation and is more an architecture than a single product. It is used as the content management system for several UK-based LOR projects, including the National Learning Network (<http://www.nln.ac.uk/>), the Seeveaz Key Skills repository and Iconex (<http://www.iconex.hull.ac.uk/>).

Xtensis keeps a very detailed student record that allows for much personalization. As well as user interface preferences (graphics, colours, text size and font) and personal bookmarks the system stores a complete history of the LOs accessed by the user. This history, combined with LO metadata can be used by the system to make ‘intelligent suggestions’ about which LOs are the best ones to present to the learner next. The factors considered by the system include:

- the language of the LO (compared with the preferred primary and secondary language of the student);
- the platform being used at the time;
- the difficulty of the LO;
- the intended age range of the LO;
- prerequisites of a LO;

- nearness in a taxonomy of subjects (i.e. LOs dealing with the same, or similar topics);
- the preferred learning style.

So far there has been little use of Xtensis as an LMS to deliver content directly to learners, so the personalization and intelligent suggestion features are yet to be extensively used. The base functionality of classifying users and LOs and making suggestions based on a mapping between them has been used (in work with Mencap) to automatically select versions of content based on users' learning difficulties or physical disabilities.

Areas that are specifically indicated as work for the future are the extension of personalised suggestion mechanisms to include factors additional to those mentioned above, and the further development and implementation of digital rights protection.

Moodle URL: <http://moodle.org>

Moodle (Modular Object-Oriented Dynamic Learning Environment) is an open source software package for producing internet-based courses and web sites. It is an ongoing development project designed to support a social constructionist framework of education. It is a system that has been developed by a single man Martin Dougiamas, as a part of his PhD Thesis. Its development started in 2001 and the current version of the platform is 1.4.

Depending on the difficulty level of the learning content and the general level of knowledge and skills of the learners, learning process can be realized dynamically. The exemplary scenario is the following: the students read the learning content and answers several questions. Based on the answers the student gave, the system determines the next screen piece of the content. In this way the navigation through the learning units will be system-guided and personalized.

Users (learners, teacher and administrators) are able to edit their own profile. This includes subscriptions to forums and watching courses. The learner has also access to the available chat rooms, information about his/her performance, upcoming events, journals, quizzes, surveys, choices, workshops, glossaries, assignments, etc. The learner has the possibility to see his/her current status or last activities in the learning environment and to maintain his/her personal calendar (monthly and weekly) which keeps track of their event transactions and much more. That gives him/her the ability to fast restore and continue the learning process and allows more flexible schedule for learning on the work place, necessarily intermixed with work tasks.

The capacity for personalization of the environment is subject to be improved further in the next main release of the product.

Atutor URL: <http://www.atutor.ca>

ATutor is an Open Source Web-based Learning Content Management System (LCMS) designed with accessibility and adaptability in mind. Administrators can install or update ATutor in minutes, and develop custom templates to give ATutor a new look. Educators can quickly assemble, package, and redistribute Web-based instructional content, easily retrieve and import prepackaged content, and conduct their courses online. Students learn in an adaptive learning environment. ATutor is the first fully inclusive LCMS, complying with the W3C WCAG 1.0 accessibility specifications at the AA+ level, allowing access to all potential learners, instructors, and administrators, including those with disabilities who may be accessing the system using assistive technologies. Conformance with W3C

XHTML 1.0 specifications ensures that ATutor is presented consistently in any standards compliant technology. ATutor has also adopted the IMS/SCORM Content Packaging specifications, allowing content developers to create reusable content that can be swapped between different e-learning systems. Content created in other IMS or SCORM conformant systems can be imported into ATutor, and visa versa. Full language support is available through the ATutor Translation Site.

ILIAS URL: <http://www.ilias.uni-koeln.de>

ILIAS allows users to create, edit and publish learning and teaching material in an integrated system with their normal web browsers. Tools for cooperative working and communication are included as well. The current version of ILIAS offers the following features: Personal desktop for each user with information about last visited courses, new mail or forum entries, Learning environment with personal annotations, test, glossary, print function, search engine and download, SCORM 1.2 and AICC compliance, Course management system, Communication features like mail system, forums and chat, Group system for collaborative work and organizing users and resources, Integrated authoring environment (Editor) to create courses even without any HTML knowledge, Support of metadata for all levels of learning objects, Context-sensitive help system for learners and authors, User and system administration interface, multilingual support.

OLAT – Online Learning and Training URL: <http://www.olat.org>

OLAT is a web-based Learning Management System (LMS) / Learning Content Management System (LCMS) used in the public sector of Switzerland. The initial development started at the University of Zuerich, Switzerland where it is deployed on the main OLAT server. Official support for OLAT is available at the OLAT-Center (Only available for Swiss university members). OLAT is open source and completely free of charge. Some interesting features of OLAT are: Course system based on ideas of IMS Learning Design (Also known as Educational Modeling Language), IMS Content Packaging support, course editor allowing creation of new courses within short time, Questionnaire/Survey system, fully based on IMS QTI v1.2.1, multilingual support etc.

IBM Lotus Virtual Classroom URL: <http://www.lotus.com/virtualclassroom>

Lotus Virtual Classroom provides a simple, cost-effective solution to assemble learners from remote locations in one place, online. Give them a format in which they can easily respond to the material presented. And distribute mission-critical information quickly and clearly.

For organizations considering a full-scale e-learning deployment, Lotus Virtual Classroom provides a solution that can help learners gradually become comfortable learning on the Web. And the solution is designed to work with an existing learning management system as well as the IBM Lotus Learning Management System.

Teachers can take advantage of Lotus Virtual Classroom to:

- Create assessments and surveys.
- Deliver a presentation.
- Demonstrate software.
- Use audio-video to add more interactivity to virtual sessions.

- Register participants online.
- Send additional reading materials to students before and after a classroom session.
- Catalog learning materials, presentations and content.
- Track attendance and assessment results.
- Assign participants to breakout sessions for small group work.

During each session, teachers can:

- Receive prompts when they've spent the allotted time on a particular topic.
- Initiate breakout sessions to divide students into virtual groups and monitor their progress using instant messaging.
- Share any application running on either their desktop or a student's desktop.
- Take advantage of attendance records and assessment results to keep a clear audit trail.
- Share agenda items with all users and speaker notes with other instructors.

Blackboard Academic Suite URL: <http://www.blackboard.com>

The Blackboard Learning System has powerful capabilities for managing courses and for tailoring instruction in order to meet student needs:

- Course Management capabilities focus on effective creation and setup of courses as well as tools for semester-to-semester migration and archiving.
- Content Authoring features include a WYSIWYG (What You See Is What You Get) editing tool that provides a rich text editing interface similar to a word processor.
- Adaptive Release means instructors can create custom learning paths by determining when students can access content items, discussions, assessments, assignments or other learning activities.
- Syllabus Builder enables instructors to upload an existing syllabus or use the built-in creation functionality to easily design and develop their own syllabus and lesson plans.
- Learning Units allow instructors to create sequenced lessons and control student navigation through those lessons.
- Course Cartridges® are created by all major publishers with pre-packaged content and course materials in the Blackboard format. Course Cartridges include materials such as additional readings, updated information, multimedia and question pools.
- Teaching and Learning Tools enable instructors to create rich term definition lists (Glossary) as well as clearly communicate their Staff Information. They also provide students with additional tools such as The Electric Blackboard®.
- Personal Information Management capabilities give students and instructors tools to better manage their work including a Calendar, Tasks and Blackboard Messages (course-based email).

Communication capabilities allow students and faculty to discuss issues online, to schedule collaborative sessions and to form groups that enable teamwork across geographic boundaries.

- Discussion Board enables threaded, asynchronous discussions. Instructors can use multiple forums around different topics and embed these into appropriate content areas.
- Group Projects support peer collaboration. Instructors can use this tool to form multiple groups of students. Each group can be given its own file exchange area, Discussion Board,
- Virtual Classroom and a Group e-mail tool to send messages to all group members.
- Virtual Classroom / Collaboration Tool supports live, synchronous interaction, through both a text-based Chat environment, as well as a full Virtual Classroom.

Assessment capabilities give instructors industry- leading tools to evaluate student learning. These features increase instructor efficiency in evaluating student performance.

- Assessments and Surveys allow instructors to deliver online, automatically scored assessments and surveys. They can create assessments from scratch or draw upon personal, institutional, or commercially available “test banks” of questions. Varied question types (e.g., True / False, Multiple Choice, Calculated) can be used.
- Assignments allow instructors to create assignment items through which students can submit their response directly into the Gradebook for easy management and tracking.
- Gradebook stores student performance results, including support for custom grading scales, grade weighting, item analysis and multiple gradebook views.
- Reporting and Performance Dashboard provides a view of student progress and indicates whether students have reviewed specific content items. It also enables usage data to be viewed for an entire course.

The Blackboard Learning System includes core capabilities that encompass enterprise scalability, multi-language support, and an open architecture that facilitates extending the system and integrating it with other applications.

- Enterprise Scalability: The Blackboard platform has a proven ability to scale to hundreds of thousands of active users.
- Multi-language Support: The Blackboard software learning environment supports most European languages and multibyte character sets such as Japanese and Chinese.
- Standards: Compliance and interoperability with industry standards (including IMS, SIF, SCORM, and NLN) is a fundamental capability of Blackboard’s software products.
- Blackboard Building Blocks (Open APIs): Our open architecture initiative, the Blackboard Building Blocks® architecture, provides a public, free software development kit (SDK) that documents Application Programming Interfaces (APIs). Clients and independent software vendors use the Building Blocks technology to create new functionality on top of the Blackboard platform or to integrate external systems with Blackboard products.
- System Integration: Blackboard’s data and system integration capabilities, enabled through the Blackboard Building Blocks architecture, allows institutions to integrate student information systems, authentication systems and other campus back-office systems with the Blackboard platform.

2. User Requirement elicitation method

VEMUS system introduces a number of highly innovative features both in the interaction with the system and in the form of collaboration that provides to learners and teachers of music. The most efficient way to design such exploratory features is in-context, through direct interactions and feedback from the users. More specifically, “in-context” conditions are created by allowing the teachers and the students to interact with software applications that may provide similar features but they do not include the overall innovative approach of VEMUS. It is particularly difficult to require from the users to propose innovative features without getting accustomed with the potential than ICT and ODL may offer in the teaching practice.

The **procedure of user requirements elicitation** can be described through two basic flows of information that took place in two phases (see figure 1). During the **first** phase a linear flow of information was attempted which was extended from initial scenarios of use to the consolidation of user input which facilitated the refinement of the scenarios of use. The initial scenarios of use draw on the IMUTUS system as well as on the initial concepts and ideas for the VEMUS system (presented through sketches and PowerPoint presentations). During this first round **four introductory workshops** (WS1, WS2, WS3, WS4) were realised in Greece, Sweden and Romania. The 35 participants were experienced music teachers (of clarinet, trumpet, saxophone, flute and recorder). They mainly worked with the IMUTUS and similar music systems to be able to be introduced to the vision and the proposed user centered development of the VEMUS system. The consolidated user input, gathered through thematic discussions and activities during the four workshops, helped in refining the **scenarios of use** and focusing on more detailed user needs. These scenarios include non-technical descriptions focusing on functionality, interaction and pedagogical considerations. Their aim was to illustrate the vision of the VEMUS environment in a concrete way.

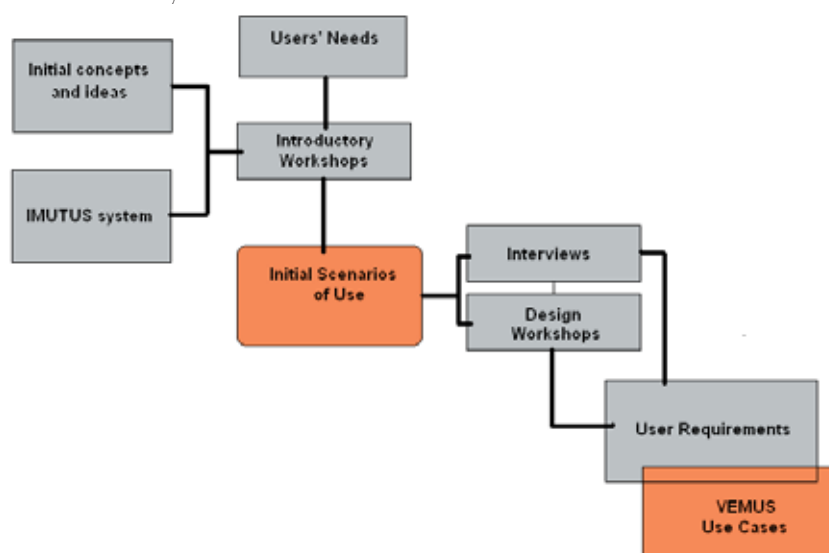


Figure 1: The procedure of requirements elicitation

The second phase started with the exposure of users to the refined scenarios of use during three **design workshops** (WS5, WS6, WS7) that were performed in Greece and Sweden and **several interviews** with more than 40 music teachers from Greece, Lithuania and Estonia, and ends with a detailed user requirements list and the VEMUS use cases, that illustrate the context of use bearing in mind specific user requirements and pedagogical issues defined during the process. Each item of the user requirements list is associated with specific information gathered during the workshops and interviews as result of the content analysis of all the transcripts from the workshops and interviews. In some cases the consortium has collected additional data through web surveys (e.g. in the case of performance evaluation) to verify the value of the teachers feedback and to assess the adopted process.

3. Introductory Workshops

VEMUS Introductory Workshops provided the opportunity for open consultation and direct feedback from actors of the music education sector. A great part of data collection for the user requirement elicitation took place during workshops with experienced music teachers. In the following paragraphs the process adopted and the main issues discussed in the framework of the workshops are described.

In general terms, the aims of the the Introductory Workshops (WS1, WS2, WS3 and WS4) were

- **to trigger discussion around the functionalities of the IMUTUS and other systems that shares the same scope as VEMUS,**
- **and to reflect on advantages and disadvantages of these systems.**

The participants were teachers of music instruments, and in particular teachers of the instruments that are expected to be supported by the VEMUS system (clarinet, trumpet, saxophone, flute and recorder).

WS1: User Requirements Workshop, November 10, 2005 (GREECE)	
Aim	To encourage the teachers to reflect on the IMUTUS system and to think how they could integrate such a system in their own teaching. The IMUTUS system is exploited as a stimulus and point of reference for envisaging the uses, benefits and difficulties of the proposed VEMUS package. Finally the current teaching practices in music education and the use of ICT in music schools and conservatories were discussed.
Venue	Athens, Greece
Participants	9 Music Teachers: 2 players of recorder, 1 trumpetist, 2 clarinettist, 1 flutist and 3 saxophonists (of which 2 play jazz and 1 classic saxophone).
Duration	Approximately two hours
Activities	1. The IMUTUS system was demonstrated in detail with the aid of a teacher of recorder. The features and potential of the IMUTUS system are explained thoroughly. The workshop participants are encouraged to interact with the system. 2. After an initial introduction of the IMUTUS system the participants are faced with the following question: “Let us imagine that the IMUTUS system could be integrated and adapted to your own teaching. - What would you change or add to the system? - What would you definitely keep? - What technical problems you think you will envisage? - What do you think are the benefits that the students will experience? - What problems will the students have? (please try to think from the student's point of view)”
Procedure	The workshop is recorded and the content is analyzed informally to have a clear understanding of how the workshop questions are answered and what further issues and questions are raised.

Tools	Pen and paper (IMUTUS handouts or brochure), data projector, audio recording system (for recording the discussion), set up of IMUTUS (recorder, microphone, speaker, etc)
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WS2 User Requirements Workshop, November 30, 2005 (GREECE)

Aim	To present music education systems for home practice and collect comments that would be useful for comparisons with IMUTUS and VEMUS systems. The systems that were selected and demonstrated were: SmartMusic (http://www.smartmusic.com/) and Harmonic Vision (http://www.harmonicvision.com/) To propose basic structure for the VEMUS system
Venue	Athens, Greece
Participants	9 Music Teachers: 2 players of recorder, 1 trumpetist, 2 clarinetist, 1 flutist and 3 saxophonists (of which 2 play jazz and 1 classic saxophone).
Duration	Approximately two hours
Activities	The systems were introduced using the video of the package that illustrates the main functions of the system. The participants of the workshop were invited to play music with their instruments and interact with the system. While introducing the system the advantages and disadvantages of the approach were discussed. Following the video demonstration and while the participants were interacting with the system a discussion was motivated based on the advantages and disadvantages of the systems.
Procedure	The workshop was recorded and the content was analyzed informally to have a clear understanding of how the workshop questions were answered and what further issues and questions were raised.

WS3 User Requirements Workshop, January 26, 2006 (SWEDEN)

Aim	To encourage the teachers to reflect on the IMUTUS system and to think how they could integrate such a system in their own teaching. The IMUTUS system is exploited as a stimulus and point of reference for envisaging the uses, benefits and difficulties of the proposed VEMUS package. Finally the current teaching practices in music education and the use of ICT in music schools and conservatories were discussed.
Venue	Stockholm, Sweden
Participants	7 Music Teachers: 3 players of recorder, 2 clarinetist and saxophonists, 2 flutist.
Duration	Approximately two hours
Activities	1. Discussion about features and pedagogical issues of the IMUTUS system that should be considered or integrated in the VEMUS system 2. Discussion on Cultural differences in teaching practices between VEMUS countries 3. Attacks, rhythmic errors, melodic errors, control of air flow, fingering technique as elements of the performance that should be included in VEMUS performance evaluation. 4. Discussion on Performance evaluation (prioritisation of errors) 5. The VEMUS music school house was proposed as a functionality that could represent the different 4-5 skill levels. 6. Feedback from performance evaluation and Real-time feedback.

Procedure	The workshop was recorded and the content was analyzed informally to have a clear understanding of how the workshop questions were answered and what further issues and questions were raised.
Tools	Pen and paper (IMUTUS handouts or brochure), data projector, audio recording system (for recording the discussion), set up of IMUTUS (recorder, microphone, speaker, etc)

WS4 User Requirements Workshop, January 30, 2006 (ROMANIA)

Aim	To encourage the teachers to reflect on the IMUTUS system and to think how they could integrate such a system in their own teaching. The IMUTUS system is exploited as a stimulus and point of reference for envisaging the uses, benefits and difficulties of the proposed VEMUS package. Finally the current teaching practices in music education and the use of ICT in music schools and conservatories were discussed.
Venue	Cluj-Napoca, Romania
Participants	11 Music Teachers: 2 players of recorder, 3 clarinettist and saxophonists, 1 flutist, 1 trumpetist, 4 teachers of music theory and Harmony
Duration	Two and half hours
Activities	1. General presentation of IMUTUS system with hands-on experience and emphasis on system functionalities 2. Discussion during the IMUTUS deployment pointed to advantage and drawbacks 3. Detailed list of requirements was developed
Procedure	The workshop was recorded and the content was analyzed informally to have a clear understanding of how the workshop questions were answered and what further issues and questions were raised.
Tools	Pen and paper (IMUTUS handouts or brochure), data projector, audio recording system (for recording the discussion), set up of IMUTUS (recorder, microphone, speaker, etc)



4. Initial Scenarios of Use

Following the realization of the Introductory Workshops the consortium designed a series of scenarios of use to act as an instrument to capture and provide a common understanding of the **functionality and merits of the envisioned system**. These initial scenarios of use give a lot of emphasis on the functional specifications of the system and they were prepared from the consortium to support the VEMUS System Requirements process. They illustrate in a meaningful way the basic aspects of the VEMUS contexts of use. The description of the functional specifications was considered important at the beginning of the user-requirement elicitation phases as VEMUS introduces a number of highly innovative features both in the interaction with the system and in the form of collaboration that provides to learners and teachers of music. These initial scenarios of use were then presented to music teachers in the framework of a second round of workshops and interviews. Additionally these scenarios were discussed between the technical and educational partners, the music teachers and students, the administrators of music schools and conservatories participating in the VEMUS project as they form the basis for the development of the **VEMUS Use Cases** that will be implemented and evaluated later in the life cycle of the project.

The initial nine (9) scenarios were organised according to the initial contexts of use proposed in VEMUS. At this level of the study it was considered necessary to design specific scenarios for each context although it is clear that the boundaries between the different contexts may merge in the framework of the use of the system.

Context	Self-Practicing Environment	Classroom Environment	Distance learning	Specific Features
Scenarios of use	•Interacting with the Score •Practicing on a Score	•Introducing a New Song in the Classroom •Following a Student's Performance in the Classroom	•Linking Two Remote Music Classes •Twinning Remote Students	•Advanced Off-Line Feedback (curves & visualizations) •Real-Time Feedback •Profiling

4.1. Structure of Scenarios of Use

The descriptions of the scenarios of use maintain an intuitive, non-technical style focusing on functionality, interaction and pedagogical considerations rather than implementation and technical details. Each scenario is given a title and its content includes the following paragraphs:

Actors & Context, listing the actors involved in the use case and providing short information on the context of this use case;

Summary, providing a short description of the use case;

Description, which includes a thorough description of the steps in interaction of the involved persons (student/teachers) and the computer(s);
In the following paragraphs the initial scenarios of use are described in detail.

A. Self-Practicing Environment

A.1 Scenario of Use: Interacting with the Score

Actors & Context

A student or any VEMUS user. The user interacts with a musical score using the VEMUS environment at his/her computer.

Summary

This scenario discusses the basic interactivity offered by the VEMUS environment that is centred around the music score. This scenario does not describe the interaction with the (off-line advanced) feedback obtained after the evaluation (see Advanced Off-Line Feedback, D.1)

Description

The student loads a song through the “Open” option on the Score toolbar. The music score is displayed on the screen with a set of tools arranged in toolbars. The student can view the information that accompanies the song, such as informational material, profiling information, general instructions. The student then starts getting familiar with the score.

He/she can switch-on annotations which are transparently overlaid on top of the score. They include the teacher annotations which can be:

Visual teacher annotations on score notes or note groups (text and shapes, handwritten text).

Audio annotations, e.g. such as oral comments recorded by the teacher, examples of correct and wrong ways of performing a note, or any other recorded audio.

Emoticons with a pre-defined meaning from a pre-defined set.

If the student has previously worked again with the piece, he/she might have kept some notes of his/her own (e.g. in the classroom during the lesson). In that case, the student can switch then on too. Moreover, if the student has previously practiced with the piece, the graphical feedback from the evaluation (see Advanced Off-Line Feedback, D.1) can also be overlaid to the score. The student can print the score (and, optionally, the annotations, notes and feedback overlaid).



Figure 2: To see the fingering of any note, the student can open the Fingering Viewer. Then, clicking on a note on the score will display the fingering of the note in 3D and 2D.

The student can listen to a **reference performance** of the song, pausing, resuming and stopping. During playback, a **cursor** moves on the score showing the current position in the score. In scores spanning to more than one page, the system automatically turns to the next **page**. The student is given some control over the playback and can configure different aspects of the playback procedure. He/she can choose:

what will actually be played-back: (a) the student's own performance (after he/she has practiced at least once with the piece); (b) A reference performance, e.g. recorded by the teacher; or (c) a MIDI version of the piece,

if a **metronome** will be used and its tempo,

if the system will play **accompanying music** (if available with the song). This may be, for example, piano music pre-recorded by the teacher, recorded performances of other pupils etc. Moreover, the student can also use more than one channels of accompanying music and control their volumes.

The student can choose to work with a **projection** of a score, representing a simplification of a score with varying degree of musical expression and sophistication, used for pedagogical purposes.

After getting familiar with the song, the student can start practicing on the score (see Practicing with a score, A.2). The behaviour and output of the system during the performance evaluation will be affected by the choice of any projections.

A.2 Scenario of Use: Practicing with a Score

Actors & Context

A student or any VEMUS user. The student practices on a musical piece on his/her own, using the VEMUS environment running locally on his/her computer.

Summary

The student uses the VEMUS environment and tools to get familiar with a music score, to practice on the score and to receive evaluation. The student can configure some of the practicing parameters.

Description

The student opens a music score. If the student is also subscribed for distance learning, the system could prompt to connect to the remote server to check for any updates and announcements published online related to the specific piece. The system displays the score on the screen. The student interacts with the score to get familiar with it. The student can practice on the entire piece or select part of it or set a loop¹.

The student can choose to increase/decrease the **tempo** of the piece, turn on the **metronome** and configure the **accompanying music** and its behaviour.

An additional parameter that the student can control is the "behaviour" of the accompanying music's tempo. He/she can choose to configure the system so that either:

¹ Practicing a loop: The behavior of the system when practicing with a loop needs to be clarified.

the system closely follows the student while playing and varies the accompanying music's tempo accordingly, or

the system tries to lead the student, by keeping the tempo of the accompanying music steady irrespectively of the variations of the tempo of the student's performance

The student notifies the system to start "listening" and starts performing. While the student performs, the system:

- records the student's performance audio;

- records the student's performance video;

- follows the student performance showing a cursor at the current position in the score and turning the score page when necessary;

- displays in real-time visual feedback on specific aspects of the student performance (see Real-Time Feedback, D.2). This feature can be switched off to avoid disturbing the student.

When the student has finished or wants to stop performing he/she notifies the system to stop recording. The student can then ask the system for a performance evaluation or can start a new performance. In the latter case the system asks the student to confirm that he/she want to discard the last performance without evaluating it. If requested, the system proceeds with the performance evaluation and when it is over, it presents the results to the student. These are:

- A grade in a predefined scale that is presented in an appropriate way to the student (e.g. in the scale of 1 to 5).

- A limited predefined number (e.g. 3) of feedback messages

- Advanced graphical feedback aligned to the score (see Advanced Off-Line Feedback, D.2).

After the evaluation, the system normalizes both the audio and the video of the student's performance. Additionally, the accompanying music is stretched to adapt to the (varying) tempo of the student's performance.

The student's profile is updated based on the evaluation results. The student can listen to any part of his/her normalized performance and interact with the score and the obtained feedback (see Advanced Off-Line Feedback, D.2). When paying-back the student's performance the system also synchronizes the score cursor as well as the recorded video.

The student can choose to store this performance (including the evaluation results, the audio and the video) for later reference or for sending it to the teacher or a peer. After finishing practicing with the piece, the student can ask the system to suggest songs / exercises. The system's suggestion is based on:

- the results of all the evaluations of the current session

- the student's profile

The system tries to find learning units that can help the student enhance the particular skills relating to most of his/her errors or the ones at which the student is relatively

weak. Through this feature, the system offers a personalized learning path tailored to the particular needs of each student. Alternatively, the student can search himself/herself for another piece to study, consulting his/her updated profile. It is very important to give the learner the option to take the decision on what to study next.

B. Classroom Environment

A “music classroom” is a term that may refer to a number of quite different settings. Some dimensions that significantly differentiate the organization and requirements of music classes are the following:

Number of participants: a teacher and a single student or many students

Place: physical vs. virtual, same place or different places

Time: synchronous vs. asynchronous, same time or different times

Classes vs. groups: teacher-student vs. peer-to-peer relations

In many occasions, the above boundaries blur especially between a real classroom setting and a distance learning environment. Thus, the proposed scenarios in this section may be relative to more than one settings as they are determined in VEMUS.

In this section two scenarios of use are presented for a traditional music class (physical, synchronous with a teacher) with more than one students. In this case, VEMUS could play the role of a teaching aid and the means to link classroom experiences with practicing at home. The proposed scenarios of use are:

Introducing a new song in the classroom

Following a student's performance in the Classroom

B.1. Scenario of Use: Introducing a New Song in the Classroom

Actors & Context

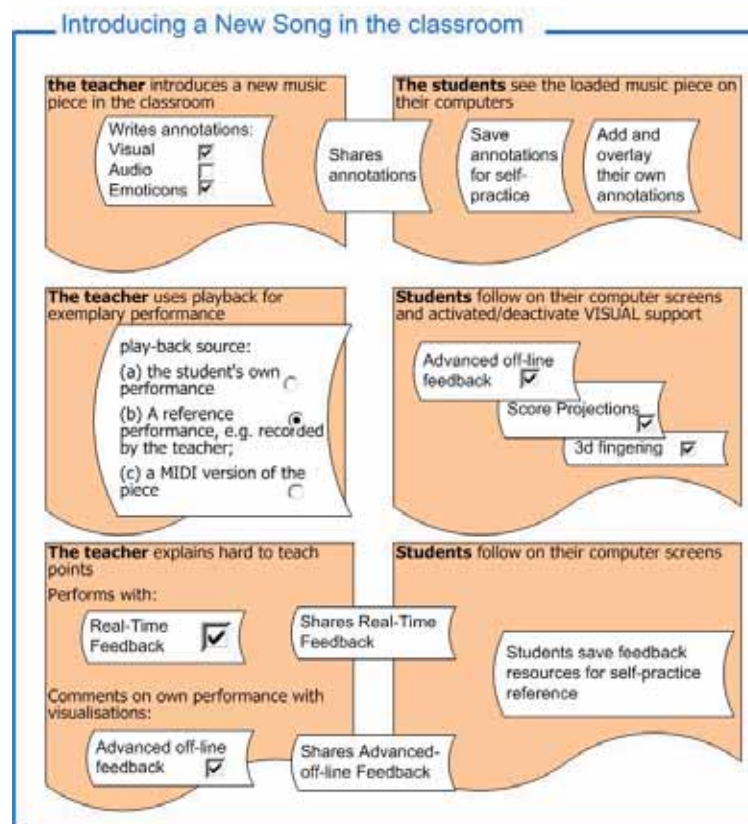
A teacher and students in a face-to-face music classroom. Each of them uses also a computer (note: This scenario requires the existence of significant technical infrastructure).

Summary

The teacher introduces a new song in the classroom, creates and shares annotations, and exploits VEMUS' performance visualization abilities to explain hard-to-teach points and to create links between classroom teaching (and experiences) and self-practicing at home.

Description

The teacher introduces a new music piece in the classroom. To this end he/she opens the electronic score of the piece on his/her computer. The score is automatically loaded in all students' computers. The teacher discusses some parts of the piece and makes (or loads pre-made) handwritten notes and visible annotations on the electronic music score. These can be general notes on the piece or notes on specific points that require special attention (e.g. points with difficult fingering transitions, additional breathing marks etc). The notes are transparently overlaid on the score and can be: handwritten textual annotations on the side of the score, annotations on a specific range of the score, special symbols (drawn



from a specifically designed symbol pool) e.g. similar to emoticons.

The notes are shared and appear at the same time on the students' screens and are automatically saved to their computers so that they can use them when practicing at home. This "automatic note-keeping" features makes resources generated in the classroom readily-available when practicing at home. At the same time, each student can also keep his/her own notes, transparently overlaid to the teacher notes and the score. The teacher uses VEMUS' playback facilities to provide an exemplar performance to the students, repeating parts of the score and pausing to make explanations as necessary.

The teacher marks a specific part of the piece that presents certain difficulties, and notifies the system to start recording. The teacher plays the selected part in a particular way to make a specific point. While he/she is playing, the students can watch real-time feedback in their own screens (see Real-Time Feedback, D.2). The teacher stops playing and uses the advanced (off-line) feedback offered by the system to present the acoustic properties and explain hard-to-teach points in practice (see Advanced Off-Line Feedback, D.2). He/she tries to correlate the playing technique with the acoustic characteristics and the respective visualizations of VEMUS' feedback. Timbre can be one of the things that are difficult to talk about and to explain. There also other such "**hard-to-teach**" points. This is the area where VEMUS' visualization is expected to be greatly appreciated.

The teacher can replay the notes in a different way and then superimpose (overlay) the visual feedback (aligned) with the previous. This step is very important since it teaches students how to **interpret** and how to **use** VEMUS' visualizations and feedback to get

a fuller understanding of their own performance (and their mistakes) and to better take advantage of VEMUS when practicing alone. At this point links are created between classroom teaching and self-practicing at home.

The teacher can ask some of the students to repeat this task and involve the rest of the students in the discussion. The resources generated during the above activities are automatically stored in all the computers and the students can refer to those when practicing alone. This functionality also provides a significant link between classroom experiences and self-practicing at home. Moreover, at the end of the lesson all the resources collected are packed into a single learning object that can be later edited and reused in different classes, or be made available online through the distance learning platform. This helps the organization (school, conservatory etc) **to progressively accumulate a corpus of learning units that can be widely reused.**

B.2. Scenario of Use: Following Students' Performance in the Classroom

Actors & Context

A teacher and students in a face-to-face music classroom. Each of them has a computer.

Summary

A student performs on a music piece in front of his/her colleagues and the teacher in a music classroom. A discussion and comments on the performance follow with the active participation of students.

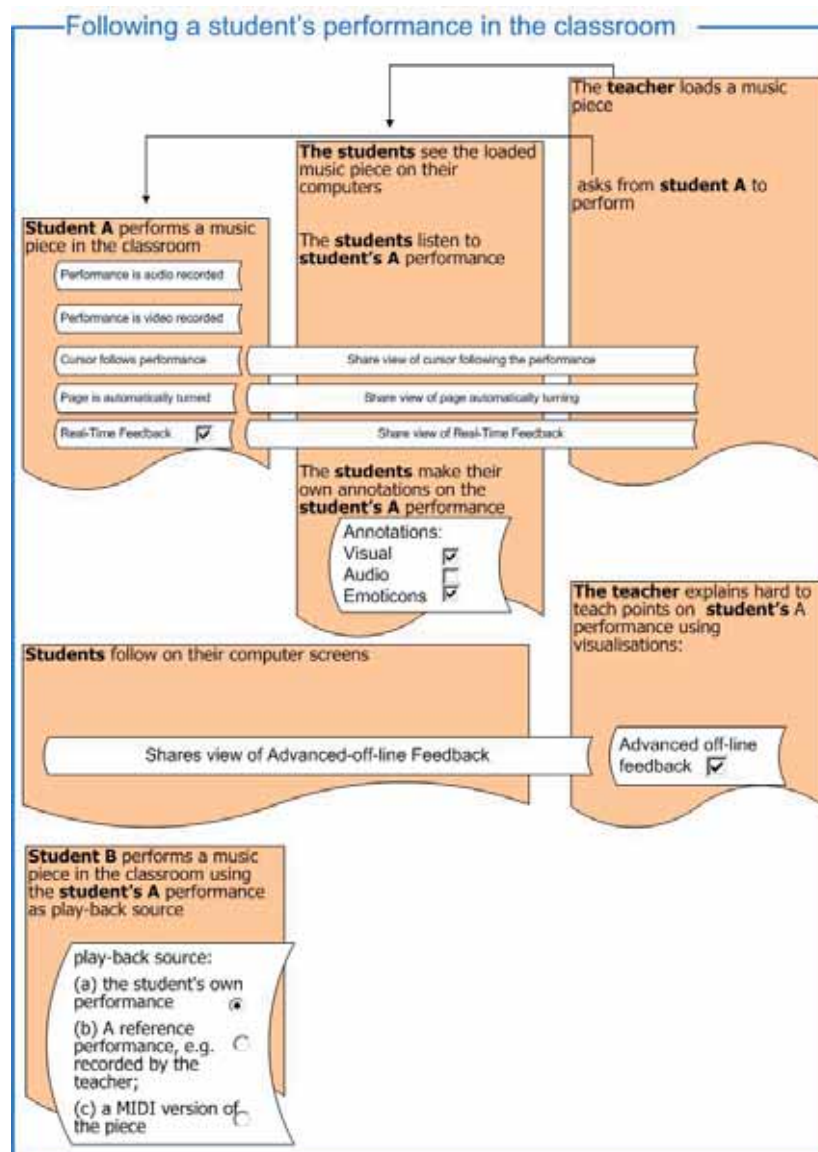
Description

The teacher opens the electronic score of the piece on his/her computer. The score is automatically loaded in all students' computers. The teacher asks a student to play the music piece and the other pupils to carefully watch and listen to the performance.

It is important to note here that most of the teaching for instrument practice in music conservatories takes place in a one-teacher to one-student setting. Things are different, of course, for music theory lessons. However, there are certain advantages in a multi-student setting. It is thought to be gainful for students to observe and listen to other pupils perform (the same or different instruments), training their ear and gaining an appreciation of playing together, as it was also presented in the VEMUS introductory workshops. The selected student starts a performance as usual using his/her local environment (see scenario in Practicing on a Score)

At the same time, the computers of all other students and the teacher display information on the performance of the selected student while he/she is playing (the teacher's computer might also be connected to a projector). They see the score cursor moving as it follows the performance of the selected student and the page turns also on their screen as necessary. Moreover, all other pupils and the teacher view visualizations of the selected student's performance while he/she is playing. This way, the teacher and the other students not only listen to the selected student's performance but also view visualizations of it in their own screen. The student performing might have real-time feedback switched off at his/her computer to avoid disruption.

At the end of the selected student's performance, all the associated data is available and shared with all the participants. The teacher then starts a conversation on the performance.



This can take place in different ways:

the teacher discusses specific aspects/mistakes of the performance and uses the visualizations to explain hard-to-teach points, make correlations of audible aspects of the performance to the visualizations and explain how to **interpret** the feedback of the system. Again, this step is very important since it teaches students how to interpret and how to **take advantage** of VEMUS' visualizations and feedback to get a fuller understanding of their own performance (and their mistakes) and to better take advantage of VEMUS when practicing alone. Links can be created between classroom teaching and self-practicing at home.

the teacher starts an open discussion with all the students asking them to provide their feedback on the performance and requesting them to justify their opinions using the visualizations and the playback abilities of the system

the teachers asks the students to make annotations on the score in order to denote specific mistakes or to praise positive aspects of the selected student's performance. To this end each student has a palette of graphical symbols or emoticons with specific meanings from which he/she can choose from and place them on specific points in the score. Each student can select and replay at his/her own computer any specific parts of the selected student's performance, and has access to the performance visualizations.

The above points encourage the active participation of students in the classroom activities. Students are learning by doing and by observing their mates. Any of the above feedback can be recorded and stored at the students' computers so that they have access to them during their practice at home, reproducing the classroom experience. Again, this provides a significant link between classroom experiences and self-practicing at home.

Different types of feedback can be recorded:

Shapes and handwritten notes by the teacher at any position on the score This is one of the most natural means of making notes and duplicates a widely used practice in traditional music teaching, replacing the pen with the so-called "digital ink".

Recorded oral comments from the teacher

Audio recordings where the teacher exemplarily executes specific groups of notes to highlight and clarify the difference between right and wrong execution of a note or a measure

All this feedback is automatically stored along with the selected student's performance in all the students' computers. Moreover, the package of the music piece, the selected student's performance and the feedback recorded as above, can be used as a learning resource in the future, and be distributed to other music classes, other pupils and distance learning platform. This helps the organization (school, conservatory etc) to progressively accumulate a corpus of learning units that can be widely reused. Finally, the teacher selects another student from the class and asks him/her to play the same song, but using the previous student's performance as accompanying music. This might be particularly useful for classes where students learn different instruments (e.g. a quartet of wind instruments) and/or different voices of the same piece.

The new student imports the previous student's performance and uses the toy-mixer to choose that as his/her accompanying music. The student then starts performing while the others are observing as before.

C. Distance Learning

C.1 Scenario of Use: Linking Two Remote Music Classes

Actors & Context

Two remote music classrooms (e.g. one in urban and one in rural area), each with a teacher and some students. There is a broadband connection between the music classrooms and teleconferencing equipment.

Summary

This scenario describes the communication between two remote music classrooms, mediated by the two teachers. The main musical activity is a performance by one student of one

classroom and the comments and evaluation from the students in the remote classroom using graphical annotations instead of spoken or written comments to overcome language barriers.

Description

At a pre-agreed time, the teachers of the two classes start a typical teleconference session using existing infrastructure. When a connection is established, a video link opens between the two classes. A web camera is necessary in each class, positioned at an appropriate place. If a projector is available, in each class the incoming video from the other class is projected.

The teachers make the introductory comments and mediate the overall discussion, by translating any messages among students.

The two teachers then also establish a connection through the VEMUS environment (synchronous remote connection mode), and choose a song to work with. The teacher of class A, selects one student from his/her class and ask him/her to perform the selected song. It is a useful experience for a student to learn to overcome the stress associated with performing not only in front of his/her mates, but also in front of people with whom he/she is not familiar.

From this point on, everything proceeds as in scenario Following a Student's Performance in the Classroom, with the difference that the performance and all the visualizations are also observed by all the students and the teacher in class B (though with some latency). After the performance, all students, including the students of class B, can make graphical annotations and/or put emoticons on the score of the selected student. Emoticons and other graphical annotations can be very important in the case of music classes from different countries, since they can facilitate communication and help overpass the language barriers. Moreover, resources employing graphical annotations can be made readily available for use in any other class at any different country.

The two classes can have an open discussion on the selected student's performance and the two teachers mediate and translate when necessary the various comments. Again, a student from class B can then play the song (with a different instrument or a different voice of the song) using the previous student's performance as accompanying music. This case can provide a very good opportunity **to bring closer children from remote places and, even, different countries**, enabling them to interact and share some common goals. Moreover, this could help create a team spirit in each of the two classrooms, with the students of the different classes "competing" and trying to give their best when representing their class.

As a variation of the above scenario, the two students from the two classes that were selected to perform, might have been remotely collaborating for some period before they perform in front of the two classes (See Twinning Remote students, C.2)

C.2. Scenario of Use: Twinning Remote Students

Actors & Context

Two or more remote students that work and study separately using VEMUS and its distance learning extensions.

Summary

Two or more students have undertaken a joint project to learn to play together a music piece. Each practices on his/her own and they periodically exchange their performances so that they can learn to play on top of each other's performance. This unsupervised setting also lends itself to groups of musicians that need to make some practicing remotely.

Description

A group of young musicians or two or more remote students have undertaken a joint project to learn to play together a music piece. The team may be learning to play different voices of the same piece, or they can even be studying different instruments.

Each one studies alone using VEMUS for their practicing at home as usual. They are able to communicate asynchronously through emails or through the VEMUS distance learning platform exchanging information on their progress. The team has set a target to have a first good performance from each by a specified day. After enough practicing one of the musicians, say Sofia, feels that she managed to make a good performance and decides to share it with her mates. To this end, she saves the performance, connects to the VEMUS distance learning platform and uploads it to a common area accessible to the others.

The other members of the team get notified that a new performance is available by Sofia, connect to the VEMUS distance learning platform and download it. They open the performance and carefully follow it also observing VEMUS' visualizations and feedback. They can put annotations and emoticons, make comments to the performance and send them back to Sofia. Moreover, they can then import that performance in their local VEMUS environment and set their toy-mixer to use that as accompanying music. This way, they can practice on top of Sofia's performance, getting "tuned". **Working on a common task and observing each other's progress can lead to a fruitful emulation that strongly motivates students to study.** The students that perform better "push" the other ones to improve and the bilateral feedback put students also in the role of informal "teachers" leading them to closer reflect on their own performance and on the performances of their mates.

As the team progresses, they continuously upload better and better versions of their performances making them available to the others, and download better and better performances from the others. At the end the team has managed to learn enough to perform in front of an audience. They can do that when their classes connect through teleconferencing or during an actual gathering of the band. The above setting is clearly an informal and unsupervised learning task that promotes independent/autonomous learning.

This scenario can also be used as part of the homework in face-to-face teaching; the teacher splits the classroom to groups and assigns to each group to study a song for a specified period. Then, the groups actually perform live together in the classroom.

D. Specific Features

D.1. Scenario of Use: Advanced Off-Line Feedback

Actors & Context

A student or any VEMUS user.

Summary

After a performance, a student or teacher uses the VEMUS environment to see the feedback visualizations and study the different aspects of the performance.

Description

Although this scenario addresses mainly the needs of music teaching, the representations discussed proved to be useful even for experienced musicians². After a performance, VEMUS displays performance visualizations as part of the system's feedback. These visualizations provide a graphical objective representation of the performance. Graphical objects can make visible sound or performance characteristics that could otherwise be difficult to describe only orally. It therefore extends the tools at the disposal of the teacher to communicate musical ideas. It also prolongs the teacher presence when practicing at home. Let's take a simple example to illustrate the idea: since sound defects may have a visible shape, this shape could be naturally associated to a teacher comment (like "look! your pitch is unstable") thus, when practicing at home, the student will be able to recognize such defect when the system will show similar shape.

The student has access to visualizations of the following: (a) onset and duration, (b) pitch, (c) dynamics, (d) timbre.

Each visualization displays a representation of the student's performance superimposed to a representation of a "prototype" reference performance so that the student gets an understanding of what is expected from him/her. Vertical alignment is used to establish the relationship between these representations. Moreover, the representations are also related to the music score, again using vertical alignment to establish this relationship. This "comparative" teaching might prove very profitable for teaching certain things. Collating the visualizations of two performances can make the dissimilarities more intuitive and evident helping the students to better realize how their own performance differs from the reference, to learn how to differentiate the qualities of the sound and, hopefully, to gain insight on how to work for improving their performances.

Below follow the suggestions for the visualization of one or more of the above. An intuitive way to represent **duration** is to use horizontal line segments which length is proportional to the expected duration. When organizing these segments in space, we're also representing the onset time information. But duration could also be coded as a relative duration deviation. Figure 3 below gives several proposals:

² Philip McLeod, Geoff Wyvill, *Visualization of Musical Pitch*, *Computer Graphics International 2003 (CGI'03)*, 2003, p. 300

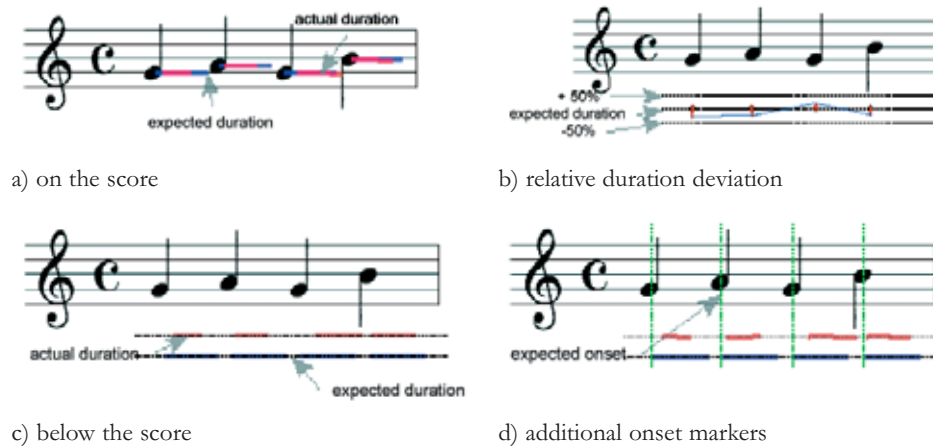


Figure 3: Duration vs. expected duration representation

- a) actual and expected duration are represented directly on the music score. The connection between graphic objects and notes is very clear. Superimposing of the actual and expected durations is managed using transparency but at first glance, it's less readable than separate time lines like in c) and d).
- b) duration is expressed as a deviation from expected duration. The onset information is not present: maybe it could be added using displacement of the dots vertically aligned to the notes. Note that relative deviation supports zoom features without zooming the score and without breaking the notes relationship.
- c) actual and expected duration are represented below the score using separate time lines. Time and duration deviations are easy to read. Connection to the notes may become less obvious with crowded scores.
- d) expected onset is drawn using vertical bars: it enforces the connection between notes and graphics.

Pitch is intuitively represented using the vertical dimension. It may be represented on the score as absolute pitch (Figure 4), or below the score as pitch deviations (Figure 5). Drawing pitch variation over time implies to represent time and therefore, x axis is used for duration.

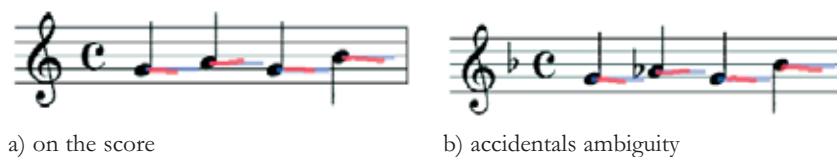


Figure 4: On score pitch representation

Representing pitch on the score has advantages and drawbacks similar to duration. Moreover, due to notes position on the staff, it is difficult to take account of accidentals: we cannot make the difference between table 2 a) and b).

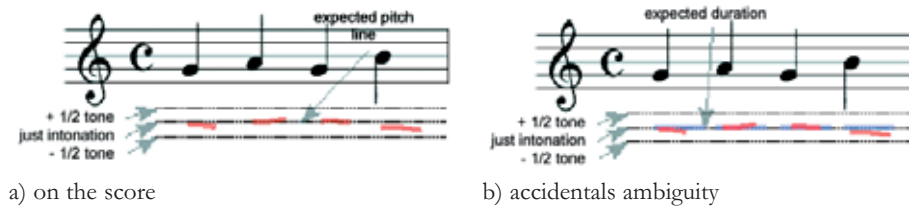


Figure 5: Pitch deviation

Pitch deviations are represented below the score. It supports zoom features similarly to duration deviation (Figure 3 c & d). Adding a reference duration (Figure 5 b) clarifies both the reference pitch and the expected duration.

Representing dynamics on the score allows to closely associate notes to actual pitch, duration and dynamic in a single graphic object. We may consider two solutions to draw dynamics: a) using line thickness, b) using colors and/or transparency.

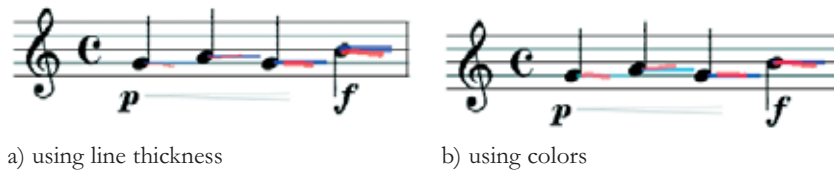


Figure 6: Dynamics represented on the score

Both solutions are less readable than the proposals below. In particular, thickness and colors lack of accuracy and make comparison more obscure.

Representing dynamics below the score allows for more accuracy as shown in figure 7. We may use continuous curves on a scale indicating the music dynamic using the y axis (7-a), duration may be part of the graph (7-b). We may also consider representing the dynamic as relative deviation from the reference dynamic (7-c).

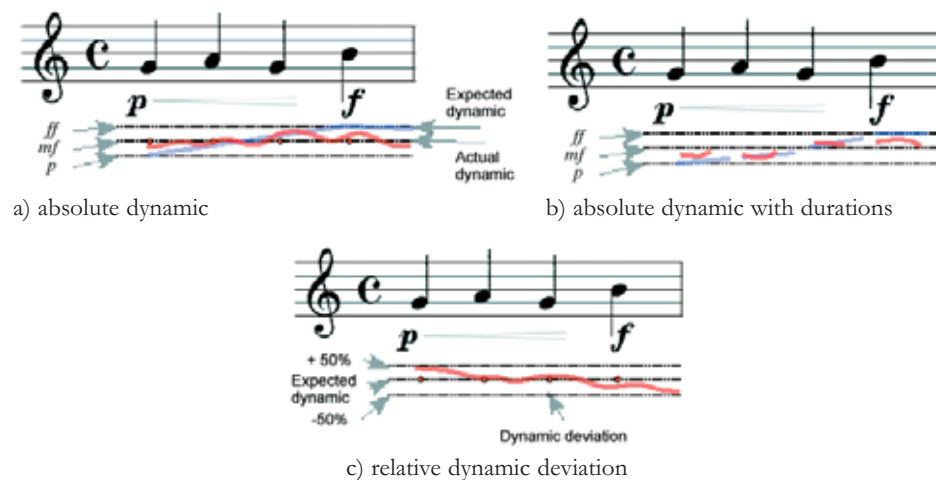


Figure 7: Dynamics represented below the score

Timbre is probably the sound characteristic that maps with difficulty onto the graphic space. The most common timbre visualization is the sonagram (or spectrogram) illustrated

in Figure 8-a. This is probably the most accurate representation but its readability should be carefully checked, especially for young musicians.

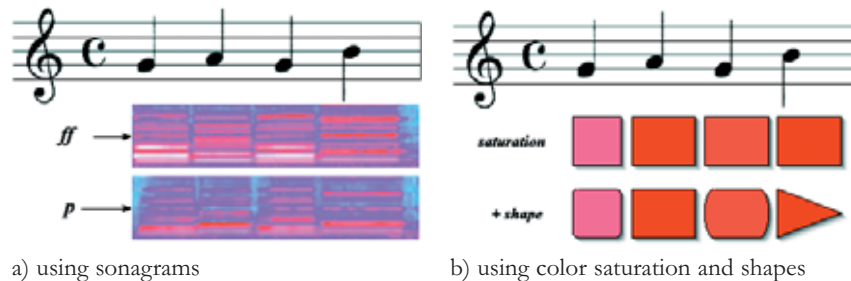


Figure 8: Timbre representation

Colors may also be used to represent timbre information: adjectives to speak about sound are already including words that easily map onto colors (like bright, dark). Some recent works³ also show that musical emotion could be mapped onto HSB colors (Hue, Saturation, Brightness). Therefore why not considering colors for representing timbre as proposed in Figure 8-b; it could also be complemented using shapes (also sometimes used to talk about sound: e.g. “un son rond” in French).

The student can choose to superimpose his/her performance to another performance instead of the reference performance, e.g. to a performance of a class mate, to one of his/her previous performances etc. The display follows again the same principles as above.

D.2. Scenario of Use: Real-Time Feedback

Actors & Context

A student or any VEMUS user.

Summary

Real-time feedback refers to visualizations of different aspects of a musical performance that are presented to the users synchronously while they perform.

Description

The Real-time feedback is mainly intended to be visual. However, audible real-time feedback might also be interesting to investigate. For example, InTheChair claims that at some times it provides spoken hints during a student performance. This kind of feedback provided by InTheChair should be examined. Should we only consider spoken hints or could we used some sounds to manifest events detected during a performance (e.g. the tempo tracker identifies that the student is continuously accelerating; or the student performance is degrading –e.g. the stability is gradually degrading from note to note).

Real-time feedback has specific advantages and disadvantages and needs to be addressed with great care. Some positive issues associated with real-time feedback are:

- it can help maintain a higher level of students’ interest since they get a direct feedback on their playing the moment it occurred rather than a deferred feedback after they have

³ Roberto Bresin, *What is the color of that music performance?* Proceedings of the International Computer Music Conference, ICMA San Francisco, 2005 pp. 367–370

concluded their entire performance.

it can be used as a means to provide a higher interactivity and a game-like interaction with VEMUS

it is well inline with VEMUS' "mirroring" paradigm

it can be very useful for short exercises focused on training specific student skills

On the other hand, a significant drawback is the fact that it might be disruptive to the student when performing. In IMUTUS, teachers clearly stated that stopping or disturbing the student during the performance should be avoided as much as possible.

According to Grame, InTheChair is an example of a system where the real-time feedback feature is more disturbing than useful. "To convince yourself make the following experiment: load "In the hall of the Mountain- King" (Grieg) and try to play with the visual real-time feedback on; when you reach the A mark, the director and the visual feedback don't agree, the visual feedback is actually one beat late and it's really confusing, it took me several times to understand what was wrong..." Based on the above, it might be appropriate to suppress real-time feedback when performing on a song, and enable it for exercises. However, VEMUS could allow the student to switch it on when he/she selects a specific part of the score to practice, for example, in a loop. Additionally, in a group setting, real-time feedback could be off for the student performing but on for the other students (and the teacher) that are listening and observing the performance.

In any case, VEMUS shouldn't provide real-time feedback at high event rate (since it'll always come too late). Real-time feedback could consist of drawing continuous information such as for example, pitch curves as shown in the Figure below.

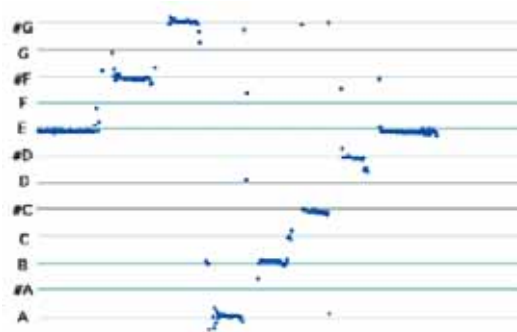


Figure 9: Pitch representation: E major scale

Finally, the real-time feedback should also be accessible in some form after the end of the performance so that teachers and students can reproduce and use it to discuss specific aspects of the performance.

D.3. Scenario of Use: Profiling

Actors & Context

A student or any VEMUS user.

Summary

A profile consists of a set of basic instrument and musical performance skills with a grade

corresponding to each skill. Instrument control skills are closely related to the specific instrument at hand while musical skills are more general.

Description

The following table summarizes the basic skills considered in IMUTUS for the recorder:

	Basic performance skill category	Average ranking	IC/MP ⁴
1	Airflow	1.7	IC
2	Fingering	1.7	IC
3	Rhythmic performance	2.0	MP
4	Attack	2.0	IC
5	Melodic performance	4.2	MP
6	Tempo	5.0	MP
7	Intonation	5.3	IC
8	Phrasing	6.0	MP
9	Articulation	7.5	IC/MP

Table 2: Basic performance skill categories, average ranking, and performance aspects. The ranking refers to the relative importance of the errors/mistakes during the first four terms of playing the recorder. Aspects of instrument control as well as musical performance are represented. Instrument control is considered most important to develop in the early stages of learning.

In VEMUS, profiling is planned to be used in two ways:

- a) to capture the current level of a student. In this case, the profile corresponds to the accomplishment of the student in each of the skills, as identified by the system.
- b) to characterize the difficulty level of a musical piece or exercise. Then the profile correlates the degree to which the mastering of each basic skill contributes to successfully coping with the piece, i.e. how demanding is a piece in terms of each of the basic skills.

Using the same profiling for both students and content, VEMUS could be able to identify weaknesses of a student (low graded basic skills), search for content that focuses on those skills and suggest that as a follow-up exercise or song. This way, VEMUS could offer personalized learning paths orienting the students to specific content that focuses on the skills they mostly need. It might also be profitable to make users aware of musical and instrument control skills as will be defined and managed by VEMUS. Students should be familiar with those concepts and terms. This way, providing them direct access to their own profiles students can have a better understanding of their own progress and make more informed decisions on what to study next, setting their own learning paths.

⁴ IC: Instrument control, MP: Musical performance



5. Design Workshops

Consolidating the music teachers' feedback who have participated in the first four introductory workshops raised specific issues which are dealt with during a second series of workshops focused on the design of the system (based on the proposed initial scenarios) in order to meet the users needs and requirements. In the discussions during these workshops, the initial scenarios of use presented in the previous section were discussed, focusing mainly on the following points:

Music classroom settings

How is music teaching organized in the different countries of the Consortium? Is the teaching of an instrument taking place in a one-to-one setting? What kind of classroom settings and organisation is needed in order the VEMUS system to work? How can collaboration in classroom, or between remote classroom sites, involving students, who work and study separately using VEMUS system and its distance learning extensions, be achieved?

Explaining hard-to-teach points in practice

How, when and what oral instructions teachers provide during a student performance? A specific part of a musical piece or a certain approach of a musical performance may present difficulties that are hard to explain. VEMUS system aims to help music learners to get a fuller understanding of their own performance (and their mistakes) and to better take advantage of VEMUS system when practicing alone. Visualizations may support the explanation of hard-to-teach points. Such points may, for example, refer to, (a) onset and duration, (b) pitch, (c) dynamics, (d) timbre.

Computer-based accompanying music in VEMUS

Accompanying music (e.g. piano), is often used in private lessons with a teacher and can prove quite helpful. Indeed studies showed that significant improvement in the ability to perform solo repertoire may come from working with accompaniment.

Personalized learning path tailored to the particular needs of each student.

VEMUS investigates the possibility of personalized remote coaching and monitoring of students' progress alleviating geographical limits and extending the relation of teachers and learners beyond the physical limits and time schedules of the classroom. This way VEMUS seamlessly blends e-learning and innovative technological enhancements with traditional face-to-face lessons to form a complete learning setting. From a different point of view, the system may need to be flexible enough to allow the learner to decide on his/her own about what to study next. The possibility to allow the student to inspect his/her own level and progress may be another available option.

Performance evaluation

The elements to be judged during a performance, based on the IMUTUS original architecture in which priority between is discussed. The criteria for the system to identify

elements to be evaluated as mistakes are a typical example of a pedagogical judgment which is implemented in the Performance Evaluation Module (PEM). Ideally, the criteria used should be related to the student's current skill.

In general terms, the aim of the the Design Workshops (WS5, WS6, WS7) was

- **to trigger discussion around the scenarios of use for the different VEMUS environments,**
- **and to develop detailed use cases for the VEMUS system.**

The participants were teachers of music instruments, and in particular teachers of the instruments that are expected to be supported by the VEMUS system (clarinet, trumpet, saxophone, flute and recorder).

VEMUS Design Workshop for eliciting user requirements (SWEDEN)	
Aim	To discuss the scenarios of use (self-practicing environment)
Venue	Stockholm, Sweden
Participants	7 Music Teachers: 3 players of recorder, 2 clarinettist and saxophonists, 2 flutist.
Duration	Approximately two and a half hours
Activities	1. Description of music classroom settings and comparison between the settings in Sweden and in Greece 2. There was a long discussion on the Initial scenarios. Still the opinion of the participants was that there is a need to focus on essentials in order to obtain a VEMUS prototype that will offer a few, well thought out features which can be successfully implemented. 3. There were specific comments about the score viewer and toolbars and the fingering viewer 4. There were many comments about computer-based accompanying music in VEMUS. From a pedagogical point of view it was concluded that there is no need for adaptive accompaniment. 5. The participants do not support the implementation of video. Their approach was that VEMUS should be only used in combination with normal lessons. During the lessons teacher has to observe posture, hand and figure positions, and breathing and to give feedback. 6. According to the participants advanced-off line feedback was judged not to be of high priority. 7. The participants support the idea that personalized learning path tailored to the particular needs of each student. 8. The classroom and the distance learning environment were not discussed in this workshop.
Procedure	The workshop was recorded and the content was analyzed informally to have a clear understanding of how the workshop questions were answered and what further issues and questions were raised.

VEMUS Design Workshop for eliciting user requirements (GREECE)	
Aim	To discuss the scenarios of use (Focus on Performance Evaluation and Specific Features)
Venue	Athens, Greece
Participants	9 Music Teachers: 2 players of recorder, 1 trumpetist, 2 clarinetist, 1 flutist and 3 saxophonists (of which 2 play jazz and 1 classic saxophone). Two members of the KTH group were also attending the workshop.
Duration	Approximately 4 hours
Activities	There was a long discussion on skills in performance evaluation and to the personalized learning path tailored to the particular needs of each student (The VEMUS music school metaphore was discussed and analysed in detail) A long series of examples of recordings were discussed and analysed from the participants. There was also a long discussion on Advanced feedback and in particular graph visualisation of pitch and dynamics and timbre.
Procedure	The workshop was recorded and the content was analyzed informally to have a clear understanding of how the workshop questions were answered and what further issues and questions were raised.

VEMUS Design Workshop for eliciting user requirements (GREECE)	
Aim	To discuss the scenarios of use (Focus on Distance Learning)
Venue	Athens, Greece
Participants	9 Music Teachers from Greece, Romania, Estonia and Sweden: 2 players of recorder, 1 trumpetist, 2 clarinetist, 1 flutist and 3 saxophonists (of which 2 play jazz and 1 classic saxophone). The workshop was realised in the framework of the PRELUDE ⁵ initial meeting. Representatives of ILSP were also present.
Duration	One day (8 hours)
Activities	The two scenarios of use (Linking two remote music classrooms and etwinning music students) were the main reference for the discussion. Participants have discussed also organisational and technical issues for the realisation of the proposed activities. Additionally the need for the creation of an advanced web repository for VEMUS was discussed in detail. There is a need for a content repository for wind instruments teaching allowing to store and retrieve not only melodies and music exercises but also text, images, and video to support the teaching. EA team has presented the case of Mesta and Ag. Nikolaos, two rural villages in the island of Chios and in Peloponnesus. EA has presented the plans for delivering distance learning courses to students (8 in Mesta and 15 in Ag. Nikolaos) through the VEMUS system. Additionally TECHNE presented similar cases in Romania. The participants have design in detail specific use cases that will meet the needs of the specific user groups.
Procedure	The workshop was recorded and the content was analyzed informally to have a clear understanding of how the workshop questions were answered and what further issues and questions were raised.

⁵ PRELUDE is a COMENIUS 2.1 project (www.ea.gr/ep/prelude). The aim of the project is to develop a methodology and training strategy in order to introduce ICT techniques in music instruction. The project brings together music teachers from Greece, UK, Romania, Sweden and Austria.



6. Interviews

Additionally to the second series of workshops a series of interviews with music teachers from the participating countries was designed and implemented. 40 teachers were interviewed on a set of questions (Appendix I) drawn from the four introductory workshops, and issues raised in the first version of the User Requirement document and the Consolidated User Feedback document. The aim was to acquire specific answers on issues generated in this first period of user requirements elicitation.

The interviews were structured around a specific set of questions. A script was produced in English, translated in Greek, Romanian and Estonian, so that similar things are discussed in each interview. The interviews lasted approximately 30 minutes. The answers to the questions were transcribed and summarised for each of the eleven questions.

The music teachers were introduced to the idea of VEMUS through small introductions as described in the script (Appendix I).

Questions addressed during the interviews covering:

Feedback Practices	What means do teachers of music use to give feedback to students while in the classroom? Verbal, visual, metaphorical? How is the feedback communicated to the learner? Is it annotated on the score? When do teachers give feedback? Do they interrupt? Do they wait for the student to complete their performance? Where is the feedback referring to?
Annotation practices	What are the most common elements of music tuition that are commented with annotation? The difference between notation and annotation should be clear.
Teacher-student interaction practices during tuition	How do learner and students interact during music tuition: Do they play together, for example? Possible reasons that interaction is only one way? How do students require the teacher's help? Do teachers impose a dull way of learning and practicing music? How could this change?



7. User Requirements for VEMUS system

The aim of this section is to present the VEMUS project understanding of practices in the teaching of wind instruments. In this section the teacher's comments and observations from the workshops and interviews are interpreted as educational needs in wind instrumental teaching that inform the user requirements. The transcripts of both rounds of workshops and of the interviews were analysed to identify what user requirements are related to the six major categories identified

- a. teaching practices
- b. studying procedures
- c. performance evaluation
- d. visualisations
- e. educational content
- f. distance learning

The transcripts from the workshops (approximately 40 pages) are indexed per paragraph. Each paragraph is coded as one or more of the above categories. Statements summarising the coded paragraphs become user requirements. The frequency of coded statement is recorded. The extracted user requirements are presented in tables for each category at the end of each of the following paragraphs. Before describing the detailed user requirements for the VEMUS system it has to be noted that **one major requirement for any advanced system like VEMUS is the provision of supporting documentation in the form of user-guide or manual.** In most of the cases the proposed **innovative procedures could possibly require from the part of the teacher to invest a lot of time in exploring the possibilities and the functionalities of the new system.** In this framework it is very important the technical and the pedagogical team of the VEMUS project to develop all the necessary documentation that should support the use of the system (in parallel with the necessary on-line support that the system has to provide). This documentation should include the VEMUS pedagogical approach, best practices for supporting each studying procedure with the help of the system, FAQ as well as simple technical guidelines. These materials should be available as soon as possible in the life cycle of the project.

7.1. Teaching practices

The main issues under discussion in this section are a) the ways teachers are providing feedback to the learners, b) the importance of the accompanying music and the ways teachers are using to correct complex and difficult to understand errors. The main requirements from a system like VEMUS are presented for each of these cases.

7.1.1. Teacher-student feedback

Instrumental tuition is often perceived as an esoteric, specialist activity, therefore there

is little documentation of how music teachers actually teach their students to play an instrument. As Hargreaves(1996) and Day (1993) point out, there is a need to develop much closer links between research and instrumental teaching. However, some researchers have focused on aspects of teaching practices, such as frequency of teacher talk, student talk, questions and student performance (Shmidt, 1989). What existing research reveals is a predominance of “technique” and “command-style” teaching strategies, suggesting an approach that is commonly described as the “master-apprentice model” (Young, 2003). Instrumental teachers tend to talk to their students in short utterances related to the previous or upcoming action about how the music should be performed in preference to performing and demonstrating it to them (Rostrall and West, 2003). In the predominant “command strategy” that is adopted by the majority of teachers, technique is the most common area of study in instrumental lessons (Swanwick, 1994; Hallam, 1997; Philpott, 2001). Often music is addressed as sight-reading exercises and it is broken down into separate notes or chords as read from sheet (Rostvall, A-L., 2003).

What literature reveals is the highly interactive relationship that enfolds between the teacher and the learner. There are clear mutual patterns in the way the teachers and students apply music and language during instrumental lessons and these patterns are closely related to each learner’s level and personality. Music teachers who participated to the workshops and the interviews consider very important that a music instruction system like VEMUS has to provide feedback according to the level and the goals of each student. The system has to provide students the opportunity to make decisions about how strict or lenient the system feedback is going to be. All the participants of the workshops and most of the interviewed music teachers stressed the pedagogical value of allowing students to play the piece to the end, especially for the beginners. For example, both Greek and Swedish teachers do generally not interrupt young students while playing to correct or give feedback. The student is allowed to play the piece to the end. Further, the teacher generally encourages the young student by giving praise as soon as there is a possibility. The basic concept is that it should be fun to play, rather than a strict educational process. However, teachers seem to give feedback while the student is playing even in a non-verbal way. Feedback is often expressed with gestures while the students perform. They raise the student’s attention with, for example, finger snapping, foot tapping or a gesture that indicates higher or lower. For example, when a student performs on a piece she knows rather well and her performance is not interrupted by mistakes or retakes, but her tempo varies. Another very important issue that was discussed in the first round of workshops (where IMUTUS system was used as a reference point) is that the **teachers expect that an instructional system like VEMUS has to evaluate and provide feedback even to an unfinished performance.**

During the discussion in the framework of the Swedish Design Workshop a series of additional requirements were identified concerning teachers’ annotations in the score. Teachers must have access to a pool of different icons and also to be able to design their own icons for instrument-specific purposes. Additionally the idea of audio annotations was considered of great pedagogical value.

Summary of Requirements for teacher-student feedback	Source
Students need to be praised and reproached according their level and their goals. They must have a choice about how strict or lenient the system's feedback is.	WS1, WS3, WS4, WS7, Interviews
Students must not be interrupted during the performance, at least during the first years of tuition	WS3, WS6, WS7, Interviews
The system should be able to provide feedback even to an unfinished performance	WS3, WS6, WS7, Interviews
There must be annotations on students score with remarks or to outline some sections of the score because of frequent errors or due to some complexity, while they play or after they have finished their performance.	WS3, WS4, Interviews
Teachers must have access to a pool of different icons to be used for annotations and also to be able to design their own icons for instrument-specific purposes. Additionally the idea of audio annotations was considered of great pedagogical value.	WS5, WS6, WS7

7.1.2 Accompanying music

Instrumental solo performance is often assisted with musical accompaniment. Interaction between accompanist and soloist is necessary in the performance experience, as it reduces the solitary practice and at the same time effect positively on the solo performers' intonation and subsequent pitch corrections (Brittin, 1993; Kantorski, 1986).

However, limited accompaniment availability sometimes inhibits this interactivity. Time spent working with accompanists may be restricted due to financial constraints and the availability of competent accompanists. Thus, severe limitations in available time or keyboard abilities of the accompanist may result in poor musical performance or necessitate selection of music that requires no accompaniment (Sheldon, D.A. et al, 1999).

Research has shown that instrumental students are largely motivated by the use of digital accompaniment compared to traditional keyboard accompaniment as it functions to make practicing less boring and more fun (Sheldon, D.A. et al, 1999). However, music teachers must determine methods that provide the best practice environment for the student soloist as digital accompaniment may not be for all students.

During the requirements process all participating teachers said that either **playing together** or **playing in turns with the student is very important because:**

- The student gains a complete understanding of the piece
- It helps keeping the beat steady and correct the mistakes on rhythm, intonation, phrasing etc
- The simultaneous performance of exercises and mostly pieces helps students to model teacher's playing.

It was also stated **that having a piano (which is usually used in such cases) in the classroom for accompaniment is often considered a luxury** but it changes and uplifts the lesson completely and thus may increase the student's motivation. During the

workshops the teachers commented on current practice with accompanying music and on the accompanying music offered by IMUTUS system. In many cases (WS1, WS2, WS3) the teachers reported that accompanying music from CD-ROM, preferably from live recordings, is used rather often during lessons and also when practicing at home. Often the melody part can be muted by turning the balance control to get music minus one.

However, as it was indicated in the Swedish introductory workshop, it should be taken into account **that accompaniment changes the student's way of playing**. Accompaniment is usually not used until the student can play the melody reasonably well, and when playing with accompaniment the student takes greater risks in order to keep tempo and avoid stopping at difficulties. In that sense **accompaniment invites to more "careless" playing**. On the other hand **accompaniment fosters the ability to continue playing despite difficulties and to complete a performance to the end**. Thus it may increase student's motivation for self-practicing, an aspect that was considered very important for the student's progress and dedication (90% of the interviewed music teachers).

Adaptive accompaniment (i.e. dynamically adapting to the students' varying tempo while they perform) may offer rather difficult technical problems. As it was concluded from both Swedish workshops **there is no need for adaptive accompaniment from a pedagogical view**. It is important though that **the student should be able to start the accompaniment from any position in the score** (indicated by moving the cursor to the starting point or mark a selection of bars). As it was remarked in WS2, in examining another software applications (SmartMusic and Harmonic Vision), it is considered important for the system to be able to intelligently monitor the student's performance. Accompanying music should pause if student is lost and resume playing the next phrase together with the student.

The Concept of "Play After Me"

In the Swedish Introductory Workshop the "Play after me" concept has been considered to be useful for dealing with complex errors (e.g. rhythm). During this mode, no text message is given on how to correct the error. Instead VEMUS system invites the student to listen to the high-lighted bars which now are played correctly from MIDI-synthesis (or from the corresponding part of the reference performance). The student repeats the bars and the procedure is repeated several times (typically 3 – 6). A simple evaluation (Right!/ Try again!) would be preferable after each repetition.

Summary of Requirements for accompanying music	Source
Accompanying music, either as playing together or playing in turns, is considered important in music learning for many reasons: it helps the students keep up with the rhythm, it increases the motivation, interest and encouragement, it fosters the ability to continue playing despite difficulties to complete a performance to the end.	WS3, WS5, WS7, Interviews
The student should be able to start the accompaniment from any position in the score	WS5, WS6, WS7, Interviews
There is no need for adaptive accompaniment from a pedagogical view but tempo should be adjustable (The system would better guide the student in keeping the tempo)	WS5, WS7, Interviews
The “Play after me” concept has been considered to be useful for dealing with complex errors (e.g. rhythm).	WS3, WS6, WS7
Accompanying music should be able to pause and wait for the student to resume his/her playing.	WS2

7.2. Studying Procedures

There appear to be many parallels between how children work individually to complete their homework and study for exams and how they practice their instrument to prepare a piece for a performance. McPherson (2005), based on a review of literature and interviews with teachers and students, identified four distinct studying strategies, two organizational strategies (keeping track of what is to be learned and defining the order of practice), an improvement strategy (how to play hard pieces) and a self-correction strategy (remedy errors). All researchers stress the importance of adopting proper studying procedures as early as possible (Manturzewska, 1990; Sloboda, et al, 1996; Williamon et al, 2000). Beginners are not always aware of where they are going wrong and have not developed appropriate aural schemata to identify and correct their own mistakes (Barry and Hallam, 2002). The problem is that most instrumental teachers do not devote time and effort on teaching students how to practice (Jorgensen, 2000). Usually they provide students with specific guidelines on how to carry on with practice at home without fostering the metacognitive activity of using a repertoire of strategies, monitoring and controlling them.

The studying process was described analytically in the Greek Introductory workshops (WS1, WS2). The guidelines usually teacher provide with their students refer to the specific approach the student has to follow during homework usually by gradually increasing the complexity of aspects that he or she should deal with (e.g. start from simply playing the notes, mainly study the fingering and the notes, then deal with articulation,...). An important goal for the teacher to set for their students is to start and finish playing a score despite the difficulties and errors (WS1, WS3). During the interviews with the music teachers and especially in the discussions on Question 5 (IntQ5), **the need for the system to give the option to the teacher to choose the studying procedure was stressed**. Similarly, in the Introductory Workshops it was considered **very important to offer the teacher the possibility to intervene to the way the student studies at home**. He or she

could define **on which parameters the learner should emphasize** and **with what order he or she should deal with those parameters**. That is, the teacher has to be capable to set out a learner-specific method for practicing at home. However, it is clear every teacher may propose a different plan. It is difficult to identify a common order or a common set of procedures. The teacher defines what parameters the learner should emphasize on and with what order he or she should deal with those parameters depending on many aspects including (according to the feedback from the interviews):

- The instrument
- The student's level
- The learning objectives
- The teacher's strategies

While a common plan and order of procedures is difficult to propose depending on the above aspects, it is possible to propose which parameters could be emphasized with regards to the music piece. IMUTUS was prepared with an option by which one parameter at a time (pitch, attacks, etc) is evaluated. This option was activated by the teacher in the invisible score annotations which can be added to each melody. The practicing and evaluation of the melodies of the homework can then be tailored to the teacher's intentions. The section on Performance Evaluation elaborates further on this.

During the Greek Introductory Workshop the participants – after the discussion with the project team – came up with the proposal (that was supported by other teachers in the following workshops), to break the practice on a music score into three modules:

1st module: The learner is playing long notes (*tenuta*). The learner receives feedback from the system, on the basis of the waveform, in a similar way as when he plays the whole melody.

2nd module: The learner plays a few notes together, e.g. one measure, and practices difficult fingering. (It was noted that the same notes may be played much easier by some instruments than by some others. The structure of the keys on the instrument and the shape of the instrument may affect the difficulty of fingering).

3rd module: The learner is playing the whole score. The skills the learner acquired from the previous modules are integrated in this module. He or she receives feedback as in IMUTUS.

Finally, if the learner receives satisfactory feedback he or she can proceed to another set of modules. There may also exist an additional module or separate option for each of the three modules: The learner could play the notes or melody with accompanying music, e.g. piano. Technically that could be possible using headphones. It was also suggested that multiple (at least three) aspects (e.g. pitch, articulation, tone quality) of evaluation and feedback should be included while the learner is practicing at home. After adequate practice the learner can activate all the parameters simultaneously and receive feedback on all of them.

7.2.1. Planning the Self-Practicing Procedure for a Song in VEMUS

While it is difficult to propose specific plans as these are dependent on many aspects it became evident in the interviews that there is a rather common way in expressing how teachers give their recommendations for self –practice. Such a **practicing plan** in VEMUS could consist of a number of specific **practicing steps** that the student should follow. For example:

Step 1: Practice on part A focusing on pitch until you get 4 stars.

Step 2: Practice on part A focusing on all aspects until you make no attack mistakes.

Step 3: Practice on entire song focusing on pitch and rhythm until get 4 stars.

Step 4: ...

In general, a practicing step has the form:

Step x: Practice on <range in song> focusing on <aspect(s)> until <condition>.

At the end of the studying procedure it is important for the student to join the parts of the piece together in order to have the feel of the whole piece. In preparing such practicing steps, the teacher could:

- a) **mark parts of the score that the student can select to practice on** (e.g. by using invisible score annotations as it was proposed in WS3)
- b) **for each step, choose to restrict the evaluation of the system to only specific types of mistakes** (e.g. evaluate pitch / rhythm / attacks only) as it was proposed in WS1 and WS3. However, in some cases a complete separation between different types of errors may be difficult as one kind of error influences another (e.g. uncertain fingering gives wrong pitches but influences note durations and rhythm as well).
- c) **specify the condition that should be met to consider that the student has successfully carried out that step** and can progress to the next.

7.2.2. Practicing Parts of a Melody

A common remark in all workshops was that it must be possible to play a part of a melody and get performance evaluation. More specifically:

the student should be able to select any part which is indicated as a phrase in the score by e.g. breathing marks or phrase slurs

the student should be able to select any part of the melody by the mouse

the system should be able to evaluate and give feedback to the learner even if the learner does not complete playing the entire music piece

7.2.3. Metronome

Students do not use metronome very often, but it should be an option as it was indicated during the discussions in the workshops.

7.2.4. Automatic Page Turning

The scrolling of the following page above the score has always been a practical difficulty, which IMUTUS design has dealt with successfully (WS1).

7.2.5. Monitoring Progress

The VEMUS system will need **to keep a record of performances for future reference**

and for monitoring the pupil's progress as it was clearly indicated from the Romanian Introductory Workshop. In this case a link with the practicing plan could be drawn, especially if the common pattern “Practice on <range in song> focusing on <aspect(s)> until <condition>” is finally adopted. Thus for a set goal or condition the system may generate a **progress report** based on

- the performance skills category (as defined in PEM)
- Student's recorded performance evaluation (for example 3 starts)
- Student's devoted time on task

7.2.6. Tuning-Up

The production of sound is a complex concept which holds prime importance for all wind instruments. It relates both to embouchure and to the control of airflow. In WS1 it was made obvious that wind instruments players often exercise on playing long notes (*tenuta*) in improving attacks and sound productions. An ability that is particularly useful to wind players is the ability to play in tune as they need to “buzz” the melody they are going to play. In order this to happen successfully, young learners need to learn to sing through their instruments while playing, in other words to learn to tune their playing with their ears rather than their eyes. This ability requires tonal audiation, a term developed by E. Gordon to describe the ability of inner-hearing and internalizing a tonal pattern (Gordon, 1995). To develop accurate intonation, students need considerable experience listening to correctly tuned musical stimuli. Tuning to a single note is the first step of improving tonal intonation. Research has shown that tuning tasks on an unaltered tone has significant effects on the perception and performance of pitch and tone quality (Owrthy, M.D., 2000). The tuner that was designed for IMUTUS system may help the development of playing in tune. Additionally in WS4 the participating teachers suggested that the instrument's tuning should be adjustable between 435 and 450 Hz for note A (1a). However, as a single note lacks context and meaning, students have to learn to tune-up in a whole melody. As soon as the student manages to get tuned to a single note he/she may choose exercises that include graded melodies with (1) no motion, (2) step motion, (3) small leaps, and (4) large leaps.

Summary of Requirements for studying procedures	Source
The teacher should be allowed to choose the studying procedure	WS1, WS3, WS4, WS5, WS6, WS7, Interviews
The teacher should have the possibility to intervene to the way the student studies at home. He or she could define on which parameters the learner should emphasize and with what order he or she should deal with those parameters	WS1, WS3, WS4, WS5, WS6, WS7, Interviews
In the self-practice lesson plan multiple (at least three) aspects (e.g. pitch, articulation, tone quality) of evaluation and feedback should be included	WS1, WS6, WS7, Interviews
The teacher should be able to mark up parts of the score for the student to practice and specify which aspects of the student performance should be evaluated by the system	WS1, WS3, WS6, WS7
In any lesson plan the teacher may identify for each music score difficulties and aspects that need special attention.	WS1, WS3, WS6, WS7
The student should be able to practice the piece in steps (i.e. practice part A, then part B, then the whole piece) and get performance evaluation.	WS1, WS3, WS6, WS7, Interviews
The teacher should be able to design and apply a practicing plan. A practicing plan would be a collection of order steps that could have similar form: Step x: Practice on <range in song> focusing on <aspect(s)> until <condition>.	WS1, WS3, WS6, WS7, Interviews
The system will need to keep a record of performances for future reference and for monitoring the pupil's progress and to generate a progress report based on a) the performance skills category, b) Student's recorded performance evaluation and c) Student's devoted time on task	WS4, Interviews
After adequate practice the learner should be able to activate all the parameters simultaneously and receive feedback on all of them.	WS4, Interviews
At the end of the studying procedure it is important for the student to join the parts of the piece together in order to have the feel of the whole piece.	WS1, Interviews
The system should provide the possibility to tuning to a single note (by means of a tuner tool).	WS1, WS4, WS6
The system should include exercises of graded difficulty for tuning up	WS6, Interviews

An attempt to associate studying procedures with VEMUS functions is proposed in the following table. This is rather a suggestion for investigating what studying strategies are supported by which functions.

Table 3: VEMUS functions that could be related to studying procedures

Commonly Used Studying Procedures	Proposed VEMUS Functions												
	Annotations	Emoticons	Advanced Off-Line Feedback	Real Time Feedback	Feedback	Accompanying music, play-back	Fingering viewer	metronome	'Play after me'	Video Recording	Tuner	Score projections	Material from content repository
Attacks	•		•		•								
Breathing exercises (airflow)	•				•					•	•		•
Embouchure (airflow)	•				•					•	•		•
Tuning exercises				•		•		•			•		•
Body posture	•									•			•
scales and other exercises			•										•
Fingering technique	•	•					•						•
Score Reading	•	•			•							•	
Rhythm	•	•	•	•	•	•		•	•			•	
Intonation (pitch)	•		•	•	•	•			•		•	•	
Articulation (staccato, legato etc)	•		•	•	•				•			•	
Dynamics (piano, forte etc)	•		•	•	•	•			•				
Timbre	•		•		•	•			•				
Practice the melody in part/ as whole	•								•				
Practice the melody in part/ as whole until you achieve...	•				•								

7.3. Performance Evaluation

As the performance evaluation is considered one of the most important issues in the VEMUS system development it has been discussed and explored in detail throughout the workshops, the interviews. Additionally a web survey was realized to support the data collection in order a commonly accepted approach to be adopted especially in the prioritization of the elements to be assessed in each performance. **It is clearly recognized that the behaviour of a system in this process should be adaptable to:**

- the student level and personal character
- the teacher preferences and the teaching style that the teacher wishes to impose

7.3.1. Elements to be evaluated during a Performance

Research on performance skills is inconsistent on the aspects that should be evaluated during a performance. Many researchers use various standardised performance-scales (Gordon, 1986; Schleuter, 1978) whilst others broaden their definition of performance skills and include factors such as technique, tone quality, music-reading ability, rhythmic ability, sight-reading ability and general musicianship (Kinedinst, 1991).

The elements to be judged during a performance, based on the IMUTUS original architecture, on experience of the members of the VEMUS consortium as well as on KTH's web survey are:

- **basic instrumental skills** (attack, gripper fingering, embouchure, posture)
- **basic musical skills** (score reading, articulation, phrasing, score writing, rhythm, tempo) and
- in a more advanced level, **skills on controlling the sound** (intonation, squeaks, tone quality, air/finger)

Another issue is related to gaining trust to the system's performance feedback which should be consistent to what a real teacher would think about a performance. This discussion was interestingly generated during the Greek Introductory workshop (WS1). The IMUTUS demonstration generated feedback on a recorder teacher's performance that was thought by the teachers to be contradictory. Specifically, teacher's performance –although it was evaluated with three stars– received comments for improvement which might be considered to be misleading. Most of the workshop participants (teachers of wind instruments) disagreed with this feedback on 'hard notes' which was considered unfair. Special care should be put during the VEMUS performance evaluation functionalities in order to avoid such contradictory assessments.

Though cultural differences in teaching practices may well exist between countries, the VEMUS system has to adopt a common strategy for the performance evaluation, and it is essential that it shares the common elements.

7.3.2. Prioritizing elements of feedback

The most important question with regards performance evaluation is rather on the priority between the elements to be assessed and how this priority changes as the student progresses. For example, at the first year of tuition emphasis is given on crisper fingering and airflow (WS1, WS6, WS7). As student progresses other aspects of perform-

ance are judged, such as expressiveness, dynamics. This issue was discussed with the music teachers during the interviews and most of them **stressed the importance of adaptability in evaluating a student's performance according to his/her level.**

The criteria for the system to identify elements to be evaluated as mistakes are a typical example of a pedagogical judgment which is implemented in **the Performance Evaluation Module (PEM)**. Ideally, the criteria used should be related to the student's current skill. The lower the level of expertise of the user (the learner) the more tolerant the system should be to mistakes (WS1). Moreover, these could be made adjustable by the teacher, making VEMUS more 'forgiving' for specific types of errors during a period. A question that was raised in most of the workshops was to whether all teachers would offer the same evaluation for a given performance. Defining the parameters of evaluation a priori, as well as the hierarchy of important skills and mistakes, may favor some consistency in evaluation. On the other hand, a predefined hierarchy of basic skills may give a "consistent" or even rigid evaluation which may not be fair in the student's eyes. **A proposal which should be considered to implement in VEMUS is to let the teacher update the error prioritization scheme for each student on a continuous basis (e.g. from week to week).**

There are several alternatives for how to use and adapt priority lists of skills as it was indicated during the Swedish Introductory Workshop (WS3). The teachers have clearly presented their preference to a system that allows for **an adaptable priority set by the teacher for each student ("Teacher's palette") including:**

- **A number of fixed settings related to age** (or better, number of semesters played). The teacher decides once per semester which setting should be used for each student.
- **Personal settings for each student.** The teacher adjusts the priority from one period to the other (monthly, weekly ...) depending on how the student proceeds. In this way the teacher can put emphasis on e.g. rhythm for two weeks, while lowering the demands on melody (correct pitches). Apart from setting the priority the teacher could also adjust the margins for detecting a certain error (e.g. how closely to the nominal music notation should a dotted rhythm (3:1) be performed in order to be judged as OK).

The VEMUS Music School House

During the Swedish Introductory Workshop, the "VEMUS music school house" was proposed as a model of the solution on how to use priority lists of skills and adapt them to each student's skill level and personal character.

The "VEMUS music school house" would have 4 – 5 floors. The students proceed through 4 – 5 skill levels during the period 9 – 14 (15) years, each level corresponding to a floor in the house. In practice, a floor will typically correspond to the melodies and exercises in some printed school for the instrument in question (e.g. 'Me and my flute.' Part II).

On each floor there are three "music teachers", one strict, one medium, and one kind type of teacher. For each teacher on each floor there exists a predefined priority list of skills and predefined margins for detecting errors, in all about 15 settings.

The task for the real music teacher is then to select the appropriate floor and assign the right type of VEMUS teacher to each student according to his/her profile. In the

following an example for this profiling mechanism is given:

“My student Stefanos is now on the 2nd floor and he needs a kind teacher.” That information can then be sent home with S. as a code which he enters into the VEMUS system. Stefanos’ performances will then be judged by a “kind” type teacher, who leaves certain errors out of account and gives rather much praise. Further, “My student Anna, on the other hand, is on the same level (floor) as Stefanos but she is more talented and ambitious and can stand a strict teacher.” Anna will consequently receive more comments on errors by VEMUS system and perform much better before she receives the same amount of praise as Stefanos.

In this way the real teacher can handle individual performance evaluation settings for many students without too much work, at the same time as VEMUS system will be reasonably well adapted to the student’s skill level and personal character.

The task to specify the 15 priority lists and margins for detecting errors for the floors and types of teachers is a rather challenging task, which first requires discussions between the teachers in all VEMUS countries, and secondly several iteration loops during the system’s development.

It should also be noted that the different target instruments pose different difficulties to the learner as it was also indicated in the Greek Introductory Workshop (WS1).

In the framework of the project a **web survey was implemented on questions regarding the prioritization between basic elements in teaching a musical instrument.** The rationale for launching the survey on the web was to capture responses from many music teachers in different countries and to obtain input from teachers outside the consortium as well. Up to the submission of this document, 87 responses have been submitted, of which 43 were from clarinet teachers, 25 from flute teachers, and 19 from saxophone teachers. Of the responses 35% were from Greece, 24% from Sweden, and 41% from 7 other countries. All responses have been checked for being reasonable. The agreement between the Swedish and Greek responses is good. The survey will remain open during the entire duration of the project. **The responses to the survey have revealed an important shift in the attention to the teaching elements from year 1 to 3.** During the first year basic instrument control elements (green) such as embouchure, control of airflow/ breathing, and postura have high priority, while issues related to musical performance, including tempo, articulation, phrasing, and score reading (blue) are close to the bottom of the list. During year 3 the situation is almost reversed. It is noteworthy, however that the instrument–control element ‘airflow/breathing’ stay among the top-prioritized elements during all three years. These findings correlate to the data from the interviews with the teachers. The music teachers who have participated in the process of requirements identification are agreeing on the elements to be assessed during the performance as well as to the order of importance of these elements. Typical examples of elements of the performance that all teachers agree on that they should be included in VEMUS performance evaluation are:

- **Attacks,**
- **rhythmic errors,**

- melodic errors,
- control of air flow, and
- fingering technique

Table 4: Pedagogical focus on teaching elements for wind instruments during the first three years of playing as obtained from the web survey (average for clarinet, flute, and saxophone).

All year 1		All year 2		All year 3	
Sum of Scores		Sum of Scores2		Sum of Scores3	
Skill	Total	Skill2	Total	Skill3	Total
Embouchure	82,6	Airflow/breath	72,3	Airflow/breath	76,8
Postura	77,9	Embouchure	70,2	Rhythm	75,9
Airflow/breath	71,2	Rhythm	69,5	Intonation	74,6
Note/finger	62,3	Postura	66,6	Tempo	74,5
Rhythm	58,6	Tempo	62,1	Phrasing	73,9
Air/finger	54,7	Note/finger	62,0	Score reading	72,4
Attack	50,6	Attack	58,3	Articulation	71,8
Grips	46,9	Intonation	56,5	Tone quality	71,6
Tempo	46,6	Score reading	56,3	Attack	67,0
Articulation	38,9	Air/finger	55,5	Embouchure	66,1
Phrasing	37,8	Phrasing	53,9	Postura	65,3
Score reading	37,3	Grips	53,2	Note/finger	64,1
Intonation	35,4	Tone quality	52,0	Air/finger	62,0
Squeaks	34,3	Articulation	51,5	Grips	60,0
Tone quality	29,7	Squeaks	39,6	Squeaks	49,4

- Basic instrument control
- Advanced instrument control
- Musical skills

7.3.3. Identifying Mistakes

The criteria for the system to identify mistakes are a typical example of a pedagogical judgment which is implemented in the Performance Evaluation Module (PEM). For instance, how the system will be able to discriminate good attacks from not so good or even unacceptable attacks (e.g. without proper use of the tongue). The criteria could be based on thresholds or “margins” used to specify the “sensitivity” of the system in detecting each type of mistake, as it was discussed in WS1. Ideally, the criteria used should be related to the student’s current skill. The lower the level of expertise of the user (the learner) the more tolerant the system should be to mistakes. There should be an effort to include that feature in VEMUS system. Moreover, these could be made adjustable by

the teacher, making VEMUS system more “forgiving” for specific types of errors during a period.

It is considered pedagogically inefficient for VEMUS system to display to the student all the mistakes it has identified. Only a small number of errors will be selected and displayed, based on a prioritization (hierarchy) of the type of errors made. Turned the other way around, this hierarchy represents the ranking of the skills the student should master (according to VEMUS view).

Finally, as it was discussed in previous sections, the system should be able to evaluate and provide feedback for:

- incomplete performances
- performances with a large number of mistakes

During the Greek Design Workshop **it was pointed out that the system should detect not only the mistakes but also plausible causes for every mistake**, for example a mistake on attack may be derived from wrong mouth position. Hints for remedying the mistakes may then be easily introduced.

7.3.4. Displaying Evaluation Results to the Student

During the Introductory Workshops in Greece, Sweden and Romania the teachers agreed to retain the basics of the IMUTUS evaluation concept:

- **Give an overall grading with 1 to 5 stars.** The grading is based on the total number of detected errors in relation to the number of notes in the piece. That means that it should be easier to get more stars with the “kind” type of VEMUS teacher in the VEMUS Music School House.
- **Show the 3 most important errors/mistakes hidden behind buttons** (4 errors for the “strict” teacher). The percentage of positive comments should vary between the three types of VEMUS teachers: roughly 25% (1 pos. every fourth comment) for the “kind” teacher, 15% for the “medium”, and 10% for the “strict” teacher.
- **The feedback is given as a text message** and high-lighted note/bar(s) to show the location of the error.

However, in WS6, WS7 **it was considered as a drawback that the performance evaluation was only provided in the form of a text, without displaying the deficiencies by elements of musical notations.** It was suggested to mark the sound by another color and to make visible the correction by signs when a performer makes a mistake, for instance (this is similar to the real-time feedback of InTheChair):

- a. upward /downward arrows for pitch
- b. left-right arrows for tempo
- c. note values for rhythm, etc.

Graphical visualisation (see section 7.4) of student performance and of reference performances will also be considered in VEMUS.

Summary of Requirements for Providing Feedback	Source
The VEMUS performance evaluation should include the following elements: • basic instrumental skills (attack, grasper fingering) • basic musical skills (score reading, articulation, phrasing, score reading, rhythm, tempo) and • in a more advanced level, skills on controlling the sound (intonation, squeaks, tone quality, air/finger)	WS1, WS3, WS4, WS5, WS6, WS7, Interviews, Web Survey
The system's performance feedback which should be consistent to what a real teacher would think about a performance.	WS1, WS3, WS6, WS7, Interviews
Teachers have to be able to adjust the criteria for evaluation making the feedback more “forgiving” for specific types of errors during a period, so the system should allow for an adaptable priority set by the teacher for each student (“Teacher’s palette”) including: • A number of fixed settings related to age (or better, number of semesters played). The teacher decides once per semester which setting should be used for each student. • Personal settings for each student. The teacher adjusts the priority from one period to the other (monthly, weekly ...) depending on how the student proceeds.	WS1, WS3, WS6, WS7, Interviews
Teachers have modelled a profiling mechanism for VEMUS System in order to adapt priority lists to each student's skill level and personal character: The VEMUS Music School House would have 4 – 5 floors. The students proceed through 4 – 5 skill levels during the period 9 – 14 (15) years, each level corresponding to a floor in the house. On each floor there are three “music teachers”, one strict, one medium, and one kind type of teacher. For each teacher on each floor there exists a predefined priority list of skills and predefined margins for detecting errors, in all about 15 settings.	WS3, WS6, WS7, Interviews
Only a small number of errors should be selected and displayed, based on a prioritization (hierarchy) of the type of errors made.	WS1, WS3, WS4, Interviews
The system should detect plausible causes for every mistake	WS1, WS3, WS6, WS7
The system has to provide assessment and feedback on incomplete performances	WS3, WS6, WS7, Interviews
The system has to provide assessment and feedback for performances with a large number of mistakes	WS1, WS3, WS6, WS7, Interviews
Teachers agreed to retain the basics of the IMUTUS evaluation concept for displaying the results to the students. Still it is considered as a drawback that the performance evaluation is only provided in the form of a text in IMUTUS, without displaying the deficiencies by elements of musical notations	WS1, WS3, WS4, WS6, WS7
The system should provide hints for remedying the mistakes to the learners	WS6

7.4. Visualizations

The VEMUS system is going to provide a set of graphical visualisations as a means to help the students better understand their performances and their errors and gain a better insight on how to play and how to improve. **Visualisations can offer a much more intuitive means for communicating about music and for expressing musical concepts. Concepts such as timbre, attacks, dynamics and pitch may well be expressed by appropriate visualisations.** These visualizations provide a graphical objective representation of the performance. Graphical objects can make visible sound or performance characteristics that could otherwise be difficult to describe only orally. It therefore extends the tools at the disposal of the teacher to communicate musical ideas. It also prolongs the teacher presence when practicing at home. It was also pointed out that **visualizations should give a general feedback on students' performance and not a detailed one.** During the Interviews it was stressed that **visualizations should have musical meaning and in a way be related to musical symbols.** In order to motivate the discussion on the visualizations issue the project team has initially presented the IMUTUS visualisations in the framework of the introductory workshops. The requirements concerning the Fingering Viewer are mainly coming from these initial discussions. The project team has additionally introduced two scenarios of use (D.1 Advanced Off-Line Feedback and D.2 On-Line Feedback) to the discussions in the framework of the Design Workshops in Greece and Sweden (WS5, WS6, WS7). The requirements concerning the feedback through visualizations are the outcome of these discussions and their based on the presentation of the specific scenarios to the participating music teachers.

7.4.1. Requirements for the Advanced Off-Line Feedback

After a performance, VEMUS system should be able to display performance visualizations as part of the system's feedback. According to the proposed scenario of use the student could have access to visualizations of the following: (a) onset and duration, (b) pitch, (c) dynamics, (d) timbre. Each visualization displays a representation of the student's performance superimposed to a representation of a "prototype" reference performance so that the student gets an understanding of what is expected from him/her. Vertical alignment is used to establish the relationship between these representations. Moreover, the representations are also related to the music score, again using vertical alignment to establish this relationship. This **"comparative"** teaching might prove very profitable for teaching certain things. Collating the visualizations of two performances can make the dissimilarities more intuitive and evident helping the students to better realize how their own performance differs from the reference, to learn how to differentiate the qualities of the sound and, hopefully, to gain insight on how to work for improving their performances. The VEMUS system is expected to graphically visualise student performances and reference performances in different ways.

7.4.2. Requirements for the Real-Time Feedback

The Real-time feedback, which is mainly intended to be visual, has specific advantages and disadvantages and needs to be addressed with great care. Some positive issues associated with real-time feedback are:

it can help maintain a higher level of students' interest since they get a direct feedback on their playing the moment it occurred rather than a deferred feedback after they have

concluded their entire performance.

it can be used as a means to provide a higher interactivity and a game-like interaction with VEMUS

it is well inline with VEMUS' "mirroring" paradigm

it can be very useful for short exercises focused on training specific student skills

On the other hand, a significant drawback is the fact that it might be disruptive to the student when performing. During the workshops and the interviews, teachers clearly stated that stopping or disturbing the student during the performance should be avoided as much as possible. Based on the above, **it might be appropriate to suppress real-time feedback when performing on a song, and enable it for exercises.** However, VEMUS could allow the student to switch it on when he/she selects a specific part of the score to practice, for example, in a loop. Additionally, **in a group setting, real-time feedback could be off for the student performing but on for the other students (and the teacher) that are listening and observing the performance.**

In any case, **VEMUS system should not provide real-time feedback at high event rate** (since it'll always come too late). Finally, **the real-time feedback should also be accessible in some form after the end of the performance so that teachers and students can reproduce and use it to discuss specific aspects of the performance.**

Based on the discussion in the framework of the Swedish workshops the real-time feedback could consist of:

Pitch: Show a stylised curve of pitch (rising / falling) during long notes in a separate window. After the performance simplified signs illustrating the pitch contour could be shown above the corresponding notes.

Tone quality: Lowered tone quality, often associated with bad intonation, is often a sign of poor control of air flow (e.g. the student is getting tired). A flashing text message "Keep blowing! More air!" could be tried.

Tempo: When an unmotivated change in tempo occurs (i.e. not caused by apparent technical difficulties) the teacher often tries to focus the student's attention by snapping the fingers or join in on the piano to keep the pulse. In VEMUS a click track which starts at the current tempo and accelerates/retards to the desired tempo could be activated temporarily. Alternatively, the cursor may be used. When a major change in tempo is detected, the cursor stops following the student's tempo and move forward with accelerating/retarding pace to the nominal tempo.

7.4.3. The Fingering Viewer

In the framework of the workshops there were some comments on the IMUTUS fingering viewer. **The positioning of fingers in the 3D simulation is not the best possible.** The 3D does not suggest how the fingers should be positioned on the recorder. It shows which keys/holes should be covered. **A static 3D fingering viewer (which shifts fingering when clicking on a new note) is of value, provided that the position, appearance and shapes of the fingers are correct. Also the amplitude of movement should be realistic.** This means, however, that in many cases it is not easy to see which holes are closed or not. **A normal fingering table with open and filled circles is a necessary supplement.** An animation of 3D fingering viewer which is synchronised with a synthesised MIDI performance of a piece was considered to be of no pedagogical value. Nonetheless, **during IMUTUS validation it turned out that pupils thought the 3D viewer to be amusing.** It was suggested **for the instruments with reed (clarinet,**

saxophone) and with mouthpiece (trumpet) to insist upon a correct position by attaching images which make visible the right position of the lips (embouchure).

7.4.4. Other Visualizations

It is thought in that graphic representation of how to use the tongue or blowing in the instrument contributes to creating a correct attack. It was also acknowledged that there is a need not only to diagnose a bad attack but also to illustrate graphically how to remedy such a mistake. Teachers proposed to have a diagram or a schema to show how a player could achieve a correct attack with the application of the tongue or by blowing more or less. Existing methods (e.g. books⁶ etc) may give some insight as to how to prepare such diagrams (see also Appendix II). Experts in wind playing stress the importance of psychomotor skills. Of the motor skills involved, the respiration process often is mentioned as the most important physical aspect of wind playing. Kohut (1985) mentions that “breath directly affects intonation, articulation and diction, vibrato, dynamic level and intensity of the tone as well as phrasing, accents, and other aspects of musical expression” (p.163).

A graphical representation of the position and motion of the tongue and lips is possible in 3D animation, but there was a question whether the pedagogical implications of that are clear. Trying to learn to control the motion of a rather “abstract” part of the body as the tongue (you don’t see it normally) by imitating an animation may be difficult. For attacks the teachers immediate feedback seems more needed than ever. The old concept of imitating speech sounds, e.g.[t] or [d] is perhaps a first-hand candidate and graphical illustration/animation second.

As sound production is of prime importance to wind instruments, a 3D representation that would support this need (illustrating airflow, attack, mouth position, et al) is required. During the last few years, multimedia and web technologies have been extensively used to develop music tuition systems and improve the efficiency of music teaching (Trollinger, 1999, McCarthy et al, 2005). The interviewed teachers also provided illustrations and instructions on air flow, tongue position, coverage of embouchure hole.

Summary of Requirements for VEMUS Visualizations	Source
The VEMUS visualizations should be simple, intuitive, not using many colors	WS5, WS6, WS7
The VEMUS visualizations should give a general feedback on students’ performance and not a detailed one	WS5, WS6, WS7
The VEMUS visualizations should have musical meaning and in a way be related to musical symbols	WS5, WS6, WS7

⁶ Johnson, K (1981) *The art of trumpet playing*. Ames, LA: Iowa State University Press

Farkas, P. (1956). *The art of horn playing*. Evanston, IL : Summy-Birchard

Boubuys, A. (1964). Lung volumes and breathing patterns in wind instrument players. *Journal of Applied Physiology*, 19

Erickson, F. (1988). *Belwin comprehensive band method*. Miami: Belwin Mills

While designing visualizations of the pitch • It is needed to have a representation for each note • An option of viewing the pitch only or the duration only would be useful	WS5, WS6, WS7
While designing visualizations of the dynamics • The line thickness is more relevant for expressing dynamics • A comprehensive graph (e.g. covering a phrase) outside the score is needed	WS5, WS6, WS7
While designing visualizations of the timbre • Using the shapes and saturation is more intuitive than using the sonograms • Between color saturation and shapes, shapes are preferable as the proposed colors are not successful at all. The colors should be represented more accurately. Maybe the color range of grey would be better to avoid many confusing colors. If shapes are to be used, a proposition is to divide the first square on the left in three parts. The first part corresponds to piano, the second to mezzo forte and the third to forte, and depending on how the student plays to have the corresponding parts filled. And with a diagonal line to represent that piano is going up to forte and vice versa.	WS5, WS6, WS7
While designing the Fingering Viewer • A static 3D fingering viewer (which shifts fingering when clicking on a new note) is of value, provided that the position, appearance and shapes of the fingers are correct. • the amplitude of movement should be realistic • A normal fingering table with open and filled circles is a necessary supplement • for the instruments with reed (clarinet, saxophone) and with mouthpiece (trumpet) images which make visible the right position of the lips (embouchure) should be included.	WS2, WS3, WS4
Graphic representations of how to use the tongue or blowing in the instrument is necessary as it contributes to creating a correct attack.	WS1, WS2, WS3
The system need not only to diagnose a bad attack but also to illustrate graphically how to remedy such a mistake	WS1, WS2, WS3
A diagram or a schema to show how a player could achieve a correct attack with the application of the tongue or by blowing more or less should be included.	WS2, WS4, WS7
As sound production is of prime importance to wind instruments, a 3D representation that would support this need (illustrating airflow, attack, mouth position, et al) is required.	WS1, WS2, WS3, WS4, WS7

7.5. Educational content

During the workshops and interviews it became evident that differences are expected in the curricula or “schools” (printed books with teaching material) among the different countries, as well as in the needs of specific instruments. However, wind instruments teachers agree that the following points should be taken into account when they discuss the type and structure of educational content used in music instruction through a system like VEMUS:

Teachers have to offer exercises and systematic technical advice on generating sound, for example in embouchure, air blowing, special sound qualities and technique (staccato, legato). Both workshops and interviews revealed that teaching wind instruments depend heavily on generating sound with the mouth. Thus a great amount of teaching has to focus on **breathing techniques, mouth position, “buzzing” techniques**. During the Introductory Workshops it was proposed to **add to VEMUS content the basics of how sound is produced correctly in wind instruments and the possibility to visualize how different blows / or tongue positions affect the attack**. In order to accommodate the need for supporting exercises in technically generating sound with the mouth, tongue, embouchure or mouth piece, the interviewed music teachers brought notes and book references. Such material may accompany the exercises and melodies to be uploaded in the VEMUS content repository. In the Romanian Introductory Workshop (WS4) it was thought necessary **to introduce some respiration and sound emission exercises (evaluated by software, too) by explaining the physiologic way of playing the winds (with images), suggesting the sensations necessary to sound emission: abdominal respiration and the differentiate dosage of air column, depending on the used instrument**. In the Greek Design Workshop (WS6), it was stressed that **to help the sound production the teachers choose preparatory exercises without the instrument itself, for example by using only the mouthpiece**. However, reservations were held on the feasibility of the system to record and consequently to give feedback on such exercises. Tuning exercises should also be included as playing in tune is a complex activity that demands physical and perceptual understanding of good intonation. However playing in tune with another voice or instrument is of primarily importance to wind instruments and pose specific to these instruments difficulties.

With regards to **repertoire, the available content should be consisted with the school-based work and to include examples from the world musical literature (known works)**. Well-known songs for children, “family tunes” and traditional (folk) songs are also very popular, even more when including the lyrics too. These are usually songs of their countries and, of course, differ significantly from country to country. **The system should also allow the scores’ conversion to the known programs (Sibelius, Finale, Encore, Mozart) as well as to allow for “connections” of the whole displayed or audio music elements with the MIDI system**. It has to be noted that the VEMUS approach to education content is not the same as other systems, for example SmartMusic, that integrate whole music methods. **The VEMUS approach is to adopt a content repository that allows teachers to upload their own exercises and melodies**.

With regards to **the organisation of the content** there are many parameters to take into account. **Teachers agree that assigning exercises and melodies to students depends**

on the level of the student, the instrument, and the preferences of the student. The selection of short exercises and simple melodies follows a **graduated order according to students' level and proficiency**. Teachers acknowledge that they often feel the need to elaborate on how they **combine short exercises and simple melodies and adopt or create existing material**. Additional melodies and exercises are used according to the needs of the student to practice more on certain difficulties. This material is distributed by the teacher as sheet music. The structure of the content is also characterised by, depending on the instrument, the order in which the notes (pitches) are introduced (e.g. starting playing in the middle or low register). With respect to **organisation of the content structure**, the “**VEMUS Music School House**”, proposed in the Swedish Design Workshop (WS5), represents an interesting way for **organising content in VEMUS** (see section 7.3).

During the interviews the music teachers said that **the educational content is expected to be updated and rearranged regularly**. Additionally **the VEMUS content repository should be equipped with functions and facilities that will allow easy access and retrieval of different materials**. Additionally a clear need for a **content repository for wind instruments teaching allowing to store and to retrieve not only melodies and music exercises but also text, images, and video to support the teaching**, was clearly identified. It was also requested that freedom should be given to the teachers to:

insert new content; either content they produce themselves or content they acquire from other sources

re-arrange the content to meet their the requirements of their own classes or schools and/or to meet their own personal teaching preferences

Summary of Requirements for Educational Content	Source
Include to VEMUS content the basics of how sound is produced correctly in wind instruments and the possibility to visualize how different blows/or tongue positions affect the attack.	WS1, WS3, WS4, WS5, WS6, WS7 Interviews
There is a need for preparatory exercises for wind instruments, which are closely linked to a successful performance. Tuning exercises should also be included.	WS1, WS3, WS4, WS5, WS6, WS7, Interviews
Teachers should be allowed to choose educational content flexibly, depending on their background, taste and preferences.	WS1, WS3, WS4, WS6, WS7, Interviews
The available content should be consisted with the school-based work and to include examples from the world musical literature (known works).	WS4, WS5, WS6, WS7
The system should also allow the scores' conversion to the known programs (Sibelius, Finale, Encore, Mozart) as well as to allow for “connections” of the whole displayed or audio music elements with the MIDI system.	WS4, WS5, WS6, WS7
The content will be organised in lessons and chapters following a logical order of increased difficulty.	WS4, WS6, WS7
As it is widely accepted by music teachers that assigning exercises and melodies to students depends on the level of the student, the instrument, and the preferences of the student, the organisation of the content according to the VEMUS Music School House seems to be an appropriate way to organise VEMUS content.	WS1, WS3, WS4, WS5, WS6, WS7, Interviews

The educational content is expected to be updated and rearranged regularly	WS4, WS6, WS7, Interviews
There is a need for a content repository for wind instruments teaching allowing storing and retrieving not only melodies and music exercises but also text, images, and video to support the teaching.	WS4, WS6, WS7, Interviews
The teachers should be able to: • insert new content; either content they produce themselves or content they acquire from other sources • re-arrange the content to meet their the requirements of their own classes or schools and/or to meet their own personal teaching preferences	Interviews

7.6. Distance learning

VEMUS will be an open system allowing new content to be authored, uploaded to the distance learning platform and made available to the students for download. Local and on-line tools will be provided to allow a teacher to **easily create learning resources and author learning objects** locally, and then upload then to the platform. The platform will provide each student with her own private virtual space. Students will be able to upload content, resources and raw material to their private virtual space. Such virtual spaces will allow students to share resources in the context of collaborative projects and activities. The VEMUS team has designed a Workshop (WS7) in order to identify needs related with the distance learning cases of use of music instruction system like VEMUS. The main outcome was the development of a targeted scenario for remote areas in Greece and Romania. In the following paragraph the case of Mesta (rural village in Chios Island in Aegean Sea) is presented in detail.

Geographical disadvantage and socioeconomic factors have kept the village of Mesta far from many of the influences of modern urban life, as can be clearly seen, for example, in architecture. Mesta is nowadays the only still inhabited wellpreserved medieval castle-village in Greece, with a small, but economically active population (around 200 in winter, which surpasses 1000 during a short peak period in August). Among the children of the village, numbering a little more than twenty, **ICT skills and music are two of the courses currently running** which have attracted considerable interest.

In particular there is currently **an interest of at least eight children in the wind musical instruments, and predominately the clarinet**, the roots of which can be traced in the long tradition of folklore clarinetists in the village. These children, who are at the same time characterised by **high levels of self-motivation for mastering ICT skills** and the internet –a reaction, apparently, of the youth to the isolation and disadvantage of the village–, are **excited by the idea of learning music through new technologies**. Besides, applications of learning music at a distance will provide the Learning and Culture Association of Mesta, as organizer of the courses, and the learners themselves with **access to resources and teaching experts** that are impossible to attain and secure

in the small scale and isolated position of the village. The application will be made possible through the broadband satellite link that is currently being installed for the Association in the school building in the framework of the Rural Wings project (FP6-Aero Integrated Project) studying the use of DVB-RCS two-way channels for the provision of broadband applications to remote rural communities.

Distance Learning

During the second Greek Design Workshop (WS7), distance learning scenarios of use were discussed. The issues raised around questions such as 'How to link two remote music classrooms', 'how to provide not only resources but also music teachers' expertise to students in remote areas' 'how VEMUS can be best used while etwinning music students'. Clearly, **the need for the creation of an advanced web repository** for VEMUS emerged strongly from the workshop discussions. The content repository for wind instruments teaching **should allow to store and retrieve not only melodies and music exercises but also text, images, and video to support the teaching.** Furthermore, all participants acknowledged that **great lack of teachers of wind instruments in rural areas.** Many **teachers would like to deliver courses to children in such areas,** whose intrinsic motivation for learning music is in many cases the greatest of rewards. However, music teachers' life style, with its numerous responsibilities not only to teach but also to attend regularly bands, orchestras and rehearsals, cannot be accommodated in rural areas.

Blended learning

Music education by distance learning is quite novel and therefore it has been very difficult to collect user requirements. The teachers who participated in the workshops may acknowledge the need for delivering instrumental music education to remote and isolated areas however they have not been involved in a distance learning situation. During this workshop (WS7) teachers stressed that **it is difficult to imagine a situation where delivery of instrumental lessons would be realized without face to face meeting. It is therefore advisable to adopt a blended learning approach.**

Blended learning **mixes various event-based activities, including face-to-face classrooms, live e-learning, and self-paced learning.** Blended learning can be accomplished through the use of **"blended" virtual and physical resources.** A typical example of this would be a combination of technology-based materials and face-to-face sessions used together to deliver instruction. This often is a mix of **traditional instructor-led teaching, synchronous online conferencing, asynchronous self-paced study,** and structured on-the-task teaching from an experienced teacher.

Summary of user requirements for distance learning music education in VEMUS	Source
There is a great need to access music resources in rural and remote areas	W7
There is great lack of teachers of wind instruments in rural areas	
The system should be able to provide support for self guided learning	W7

The system should allow for automatic performance evaluation	W7
The users need on-line support (synchronous or asynchronous)	
Teachers should be supported by the system to easily create learning resources and author learning objects to support distance learners	W7
The educational content is expected to be updated and rearranged regularly	WS4, WS6, WS7, Interviews
There is a need for a content repository for wind instruments teaching allowing storing and retrieving not only melodies and music exercises but also text, images, and video to support the teaching.	WS4, WS6, WS7, Interviews

7.7. Other Considerations

7.7.1. Students' Attitudes towards Practicing with VEMUS

During the workshops discussions and the interviews students' attitudes towards practicing with VEMUS system was also considered. In the Introductory Workshops it was considered whether **asking from a student to record on a microphone would raise some issues**. Recording music often signifies for a musician that he or she is ready to perform in front of an audience or a recording source. Students may be put off by this concept. A way to avoid such reaction is to allow playing segments of the music text, accepting less perfect performances, and evaluate the segments as well as the whole piece. The experience from the IMUTUS evaluation was that the students were inspired to practice when someone "listened" and evaluated the performance. They were definitively more concentrated while practicing than their mates in the reference group who played in front of a music stand with sheet music. In the framework of the Introductory Workshops also the question was posed whether some **students will be put off by feeling a pressure to perform almost perfectly every time** in front of VEMUS system? The answer was "yes", some students may feel "observed". The field tests with IMUTUS showed that some (ambitious) students interrupted their playing when they played something wrong and started all over again. However, in most cases the students wanted to see that they **improved their own performance as they practiced over and over again**. Above all they wanted to receive more stars in the grading. The result was that they were concentrated when practicing, focussing on the things that went wrong last time. In that respect, the knowledge of being evaluated after each performance exerts a positive pressure to do better than last time.

7.7.2. Supporting the Role of the Parent

In the Greek Introductory Workshop it was discussed that the system should support the role of the parent or of someone who is not familiar with music but who wants to follow the learner's progress. **It would be desirable for VEMUS to give to the parent simple and understandable information with regards to the progress and maybe tips for helping the parent to support the student.** However, this was not considered to be easy. It will even be rather difficult to give a meaningful summary to the teacher regarding the progress during a week's practicing at home in terms of trends in types of errors and error rates.

Teacher- student feedback

Students need to be praised and reproached according their level and their goals. They must have a choice about how strict or lenient the system's feedback is.

Students must not be interrupted during the performance

The system should be able to provide feedback even to an unfinished performance

There must be annotations on students score with remarks or to outline some sections of the score because of frequent errors or due to some complexity, while they play or after they have finished their performance.

Teachers must have access to a pool of different icons to be used for annotations and also to be able to design their own icons for instrument-specific purposes. Additionally the idea of audio annotations was considered of great pedagogical value.

Providing Feedback

The VEMUS performance evaluation should include the following elements:

- **basic instrumental skills** (attack, grisper fingering)
- **basic musical skills** (score reading, articulation, phrasing, score reading, rhythm, tempo) and
- in a more advanced level, **skills on controlling the sound** (intonation, squeaks, tone quality, air/finger)

The system's performance feedback which should be consistent to what a real teacher would think about a performance.

Teachers have to be able to adjust the criteria for evaluation making the feedback more "forgiving" for specific types of errors during a period, so the system should allow for an adaptable priority set by the teacher for each student ("Teacher's palette") including:

- A number of fixed settings related to age
- Personal settings for each student.

Teachers have modelled a profiling mechanism for VEMUS System in order to adapt priority lists to each student's skill level and personal character: The VEMUS Music School House would have 4 – 5 floors. The students proceed through 4 – 5 skill levels during the period 9 – 14 (15) years, each level corresponding to a floor in the house.

Only a small number of errors should be selected and displayed, based on a prioritization (hierarchy) of the type of errors made.

The system should detect plausible causes for every mistake

The system has to provide assessment and feedback on incomplete performances

The system has to provide assessment and feedback for performances with a large number of mistakes

Teachers agreed to retain the basics of the IMUTUS evaluation concept for displaying the results to the students. Still it is considered as a drawback that the performance evaluation is only provided in the form of a text in IMUTUS, without displaying the deficiencies by elements of musical notations

The system should provide hints for remedying the mistakes to the learners

Accompanying music

Accompanying music, either as playing together or playing in turns, is considered important in music learning for many reasons: it helps the students keep up with the rhythm, it increases the motivation, interest and encouragement, it fosters the ability to continue playing despite difficulties to complete a performance to the end.

The student should be able to start the accompaniment from any position in the score

There is no need for adaptive accompaniment from a pedagogical view but tempo should be adjustable (The system would better guide the student in keeping the tempo)

The "Play after me" concept has been considered to be useful for dealing with complex errors (e.g. rhythm).



Distance learning music education in VEMUS

There is a great need to access music resources in rural and remote areas

There is great lack of teachers of wind instruments in rural areas

The system should be able to provide support for self guided learning

The system should allow for automatic performance evaluation

The users need on-line support (synchronous or asynchronous)

Teachers should be supported by the system to easily create learning resources and author learning objects to support distance learners

The educational content is expected to be updated and rearranged regularly

There is a need for a content repository for wind instruments teaching allowing storing and retrieving not only melodies and music exercises but also text, images, and video to support the teaching.

for VEMUS system

Studying procedures
The teacher should be allowed to choose the studying procedure
The teacher should have the possibility to intervene to the way the student studies at home. He or she could define on which parameters the learner should emphasize and with what order he or she should deal with those parameters
In the self-practice lesson plan multiple (at least three) aspects (e.g. pitch, articulation, tone quality) of evaluation and feedback should be included
The teacher should be able to mark up parts of the score for the student to practice and specify which aspects of the student performance should be evaluated by the system
In any lesson plan the teacher may identify for each music score difficulties and aspects that need special attention.
The student should be able to practice the piece in steps (i.e. practice part A, then part B, then the whole piece) and get performance evaluation.
The teacher should be able to design and apply a practicing plan. A practicing plan would be a collection of order steps that could have similar form: Step x: Practice on <range in song> focusing on <aspect(s)> until <condition>.
The system will need to keep a record of performances for future reference and for monitoring the pupil's progress and to generate a progress report based on a) the performance skills category, b) Student's recorded performance evaluation and c) Student's devoted time on task
After adequate practice the learner should be able to activate all the parameters simultaneously and receive feedback on all of them.
At the end of the studying procedure it is important for the student to join the parts of the piece together in order to have the feel of the whole piece.
The system should provide the possibility to tuning to a single note (by means of a tuner tool).
The system should include exercises of graded difficulty for tuning up.

VEMUS Visualizations
The VEMUS visualizations should be simple, intuitive, not using many colors
The VEMUS visualizations should give a general feedback on students' performance and not a detailed one
The VEMUS visualizations should have musical meaning and in a way be related to musical symbols
While designing visualizations of the pitch • It is needed to have a representation for each note • An option of viewing the pitch only or the duration only would be useful
While designing visualizations of the dynamics • The line thickness is more relevant for expressing dynamics • A comprehensive graph (e.g. covering a phrase) outside the score is needed
While designing visualizations of the timbre • Using the shapes and saturation is more intuitive than using the sonograms • Between color saturation and shapes, shapes are preferable as the proposed colors are not successful at all. The colors should be represented more accurately. Maybe the color range of grey would be better to avoid many confusing colors.
While designing the Fingering Viewer • A static 3D fingering viewer (which shifts fingering when clicking on a new note) is of value, provided that the position, appearance and shapes of the fingers are correct. • the amplitude of movement should be realistic • A normal fingering table with open and filled circles is a necessary supplement • for the instruments with reed (clarinet, saxophone) and with mouthpiece (trumpet) images which make visible the right position of the lips (embouchure) should be included.
Graphic representations of how to use the tongue or blowing in the instrument is necessary as it contributes to creating a correct attack.
The system need not only to diagnose a bad attack but also to illustrate graphically how to remedy such a mistake
A diagram or a schema to show how a player could achieve a correct attack with the application of the tongue or by blowing more or less should be included.
As sound production is of prime importance to wind instruments, a 3D representation that would support this need (illustrating airflow, attack, mouth position, et al) is required.

Educational Content
Include to VEMUS content the basics of how sound is produced correctly in wind instruments and the possibility to visualize how different blows/or tongue positions affect the attack.
There is a need for preparatory exercises for wind instruments, which are closely linked to a successful performance.
Teachers should be allowed to choose educational content flexibly, depending on their background, taste and preferences.
The available content should be consisted with the school-based work and to include examples from the world musical literature (known works).
The system should also allow the scores' conversion to the known programs (Sibelius, Finale, Encore, Mozart) as well as to allow for "connections" of the whole displayed or audio music elements with the MIDI system.
The content will be organised in lessons and chapters following a logical order of increased difficulty.
As it is widely accepted by music teachers that assigning exercises and melodies to students depends on the level of the student, the instrument, and the preferences of the student, the organisation of the content according to the VEMUS Music School House seems to be an appropriate way to organise VEMUS content.
The educational content is expected to be updated and rearranged regularly
There is a need for a content repository for wind instruments teaching allowing storing and retrieving not only melodies and music exercises but also text, images, and video to support the teaching.
The teachers should be able to: • insert new content; either content they produce themselves or content they acquire from other sources • re-arrange the content to meet their the requirements of their own classes or schools and/or to meet their own personal teaching preferences



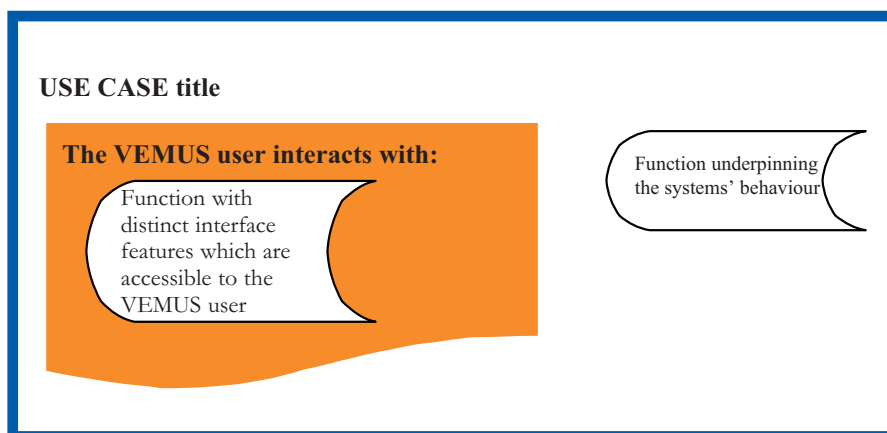
8. Use Cases

This Section describes a series of proposed VEMUS use cases. These use cases are based on initial VEMUS scenarios and at the same time demonstrate possible interconnections between the three different VEMUS environments. The proposed use cases, clearly, are not the only ones that will be deployed in the different pilot sites of VEMUS. The project team will try to develop further use cases (or appropriately modify these ones) in order to cover the needs of the system's users. These use cases though can form the basis for the extended evaluation and validation period that will follow the release of the prototype. Additionally their aim is to bridge the user requirements with the system's specifications.

As already described in previous sections, the analysis of collected data resulted in the definition of a **detailed requirements list**. The **set of use cases** that are presented in this section illustrate the VEMUS context of use bearing in mind user requirements that are related to specific pedagogical issues.

Each use case is given a title and its content includes the following paragraphs:

- **Actors & Context**, listing the actors involved in the use case and providing short information on the context of this use case;
- **Summary**, providing a short description of the use case;
- **Description**, which describes the interaction of the involved persons (student/teachers) with interface features and other computer-based functions. In this part, user requirements are explicitly related to the description. **User-Interface** sketches are also included in order to illustrate better the described ideas and organize the functionalities rather than actually presenting a view of the VEMUS user interface which can be expected to significantly differ from the figures in this text.



- **Summary of use case functions**, giving a diagrammatic summary of the functions involved in the description of the use case. Most of the featured functions are related to interface functionality. These are **functions with distinct interface features which are accessible to the VEMUS user**.

Each use case has been designed to meet a series of requirements that are presented at the end of each case.

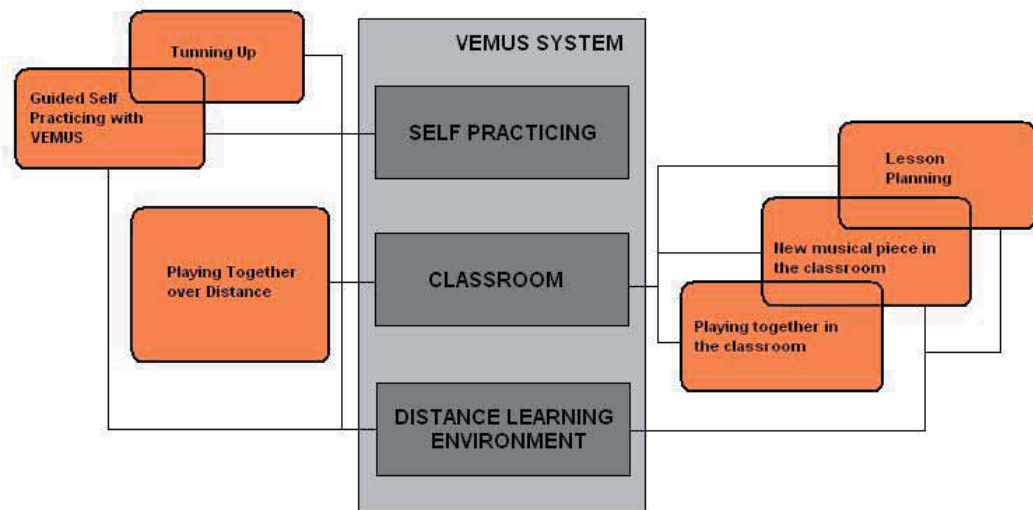


Figure 10: The proposed use cases are demonstrating possible ways to interconnect the different VEMUS environments and their functionalities. The users of the system are going to use the different functionalities of the VEMUS environments in the framework of their activities (teaching or learning) which have to be presented to them through an integrated approach. The aim of the use cases is to create realistic application scenarios, based on user needs, that will allow the systematic evaluation of the system' impact on music instruction in comparison with the ordinary tasks and activities of the VEMUS users.

8.1. Use Case: Guided Self-practicing with VEMUS

Actors & Context

A VEMUS user with some experience in using a system: The student self-practices with the VEMUS environment using his/her computer at home

Summary

This scenario describes a session, of 30-40 minutes approximately, of practicing with any VEMUS wind instrument. The student opens VEMUS environment and faces several tools and options. The selected musical score is displayed with the teachers and student's text annotations, audio annotations and emoticons. The student can follow specific Instructions.

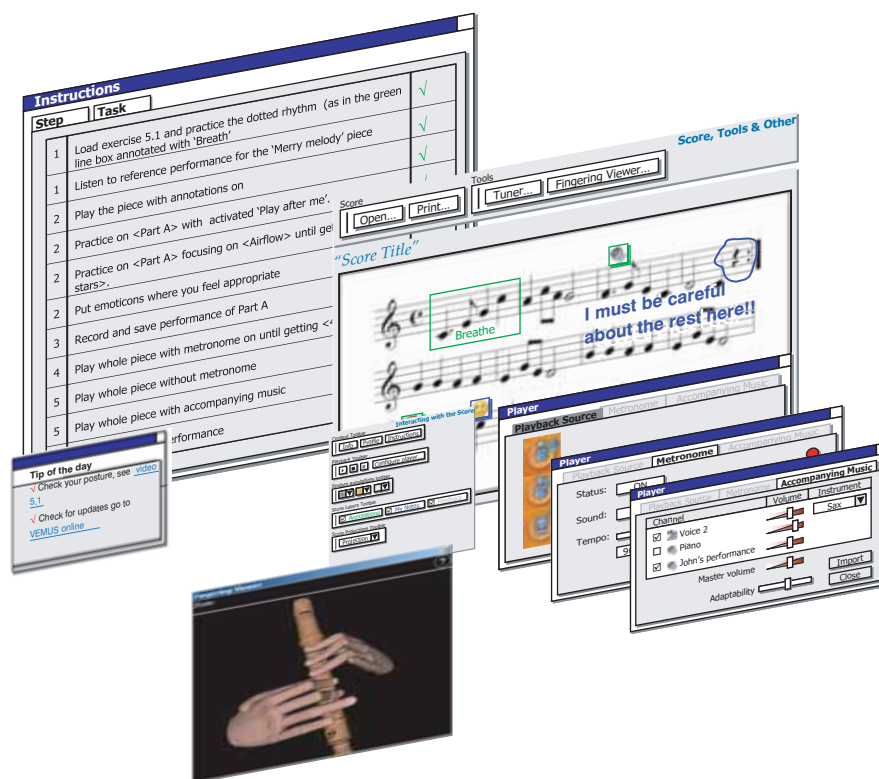


Figure 11: VEMUS self-practice environment and tools

Description

The student opens VEMUS environment and faces several tools and options (Figure 10). It is assumed he/she is already familiar with most of the functions. Piano music is the most popular “Accompanying music”. The “Playback Source” is for listening to a reference performance, and, here, a reference performance recorded by the teacher is available. The “metronome” settings are adjusted following the original score indications. The “Fingering Viewer” showing the positioning of fingers in a 3D simulation can be switched on. The **Tip of the Day** prompts him/her to connect to the remote server to check for any updates and announcements published online (“**Check for updates go to VEMUS online**”). The Tip of the day window indicates that a **video** taped performance

of the music piece is also available online.

Instructions		
Step	Task	
1	Load the “Merry Melody” song and practice the dotted rhythm, as in the green line box annotated with ‘Breath’	✓
1	Listen to reference performance for the ‘Merry melody’ piece	✓
1	Play the piece with annotations on	✓
2	Practice on <Part A> focusing on <Airflow> until getting <4 stars>	✓
2	Practice on <Part A> with accompanying music on	✓
3	Put your emoticons where you feel appropriate	✓
4	Play whole piece without metronome	
4	Play whole piece with accompanying music	✗
5	Play whole piece until getting <4 stars>.	✗
6	Record your best performance	

Figure 12: List steps and corresponding tasks for an Instruction list

“**Instructions**” refer to studying procedures and aim to guide the student through a self-practice plan as suggested by the teacher. This also helps the student to schedule his/her practice conveniently. He/She may stop practice and resume later, load the Instructions window at a later time or at a different day, keeping track of his/her progress and to-do tasks, or even save the Instruction list and send it to his/her teacher. The Instructions list comprises here six steps (Figure 12). A step may refer to more than one task that should be ticked off.

The student follows the instructions in the suggested order, and ticks off if he/she thinks he/she has successfully completed the task. In list above (Figure 12), two tasks are left incomplete while two were not completed successfully.

Following **step 1** of the ‘**Instructions**’ the student is asked to activate visual support as provided by **visual annotations and emoticons, and audio annotations** (Load the “Merry Melody” song and practice the dotted rhythm, as in the green line box annotated with ‘Breath’). While the student is visually helped by the annotations he/she is also helped by listening to the **reference performance** for the ‘Merry melody’ piece.

According to **step 2** of the Instructions, the student is practicing with a specific goal, the achievement of which is evaluated by the system in the form of stars. Here, the student is effectively getting **feedback form the system** according to the level of VEMUS music school house where he/she is assigned (“Practice on <Part A> focusing on <Airflow> until getting <4 stars>”) and with regards to a specific skill. Once the skill is acquired then the student moves on to playing the same part with the accompanying music. The student can play any selected part with the accompanying music. She does not have to play the whole piece every time.

With **step 3** the student is invited to reflect on the performance's difficulties and joys ("Put your emoticons where you feel appropriate"). Assuming that the student has almost perfected her performance, **in the 4th step** he/she drops the use of the metronome and plays with the piano accompanying music. **Step 5** suggests to the student to "Play the piece until getting <4 stars>", triggering feedback from the system in a similar way as in Step 2. In the **6th and final step** the student is asked to record his/her best performance.

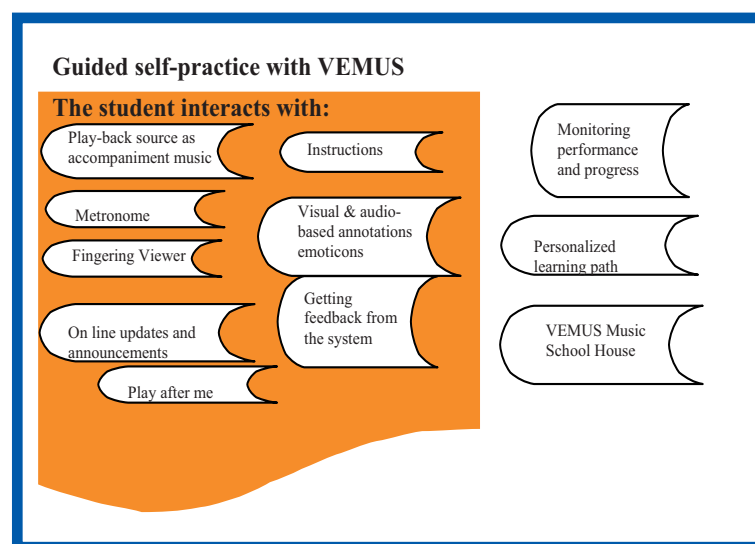
The student may also use functions that are not proposed by the Instructions. Here, for example, although the **"Play after me"** was not instructed the student is making use of it. The student listens to the selected bars (underlined with red), which are played correctly from the corresponding part of the reference performance, and then plays. Students are allowed to divert from the planned Instructions without hesitating to show it to the teacher. The student is relaxed with his/her self-practice while the teacher can see what the student's preferences and weaknesses are.

Every time the student "saves" a performance, a record of what he/she is doing on the VEMUS interface is saved in a log file, thus keeping a record from **monitoring the performance and progress** of the student. This includes a student's last saved recorded performance with musical piece data (composer, title etc.), feedback errors from the system on the last saved performance, evaluation of performance from the system (PEM) on the same performance, settings of playback sources (e.g. she used piano accompanying music) chosen when recording performance, features used before saving and after last saving (e.g. used 3D fingering viewer), time elapsed since previous saving (if existing otherwise since opening the system) and completed tasks as shown on the Instructions list.

After finishing practicing with the piece, the system may suggest to the student musical pieces and or exercises, based on a **personalised learning path**. **The system's suggestion is based on:**

- the results of all the evaluations of the current session (lookup term Practicing Session)
- the student's profile

Summary of use case functions



Guided Self-practicing with VEMUS

Teacher- student feedback

Students need to be praised and reproached according their level and their goals. They must have a choice about how strict or lenient the system's feedback is.

There must be annotations on students score with remarks or to outline some sections of the score because of frequent errors or due to some complexity, while they play or after they have finished their performance.

Accompanying music

Accompanying music, either as playing together or playing in turns, is considered important in music learning for many reasons: it helps the students keep up with the rhythm, it increases the motivation, interest and encouragement, it fosters the ability to continue playing despite difficulties to complete a performance to the end.

The student should be able to start the accompaniment from any position in the score

The "Play after me" concept has been considered to be useful for dealing with complex errors (e.g. rhythm).

Studying procedures

The teacher should be allowed to choose the studying procedure

The teacher should have the possibility to intervene to the way the student studies at home. He or she could define on which parameters the learner should emphasize and with what order he or she should deal with those parameters

The student should be able to practice the piece in steps (i.e. practice part A, then part B, then the whole piece) and get performance evaluation.

The teacher should be able to design and apply a practicing plan. A practicing plan would be a collection of order steps that could have similar form: Step x: Practice on <range in song> focusing on <aspect(s)> until <condition>.

The system will need to keep a record of performances for future reference and for monitoring the pupil's progress and to generate a progress report based on a) the performance skills category, b) Student's recorded performance evaluation and c) Student's devoted time on task

Providing Feedback

Teachers have to be able to adjust the criteria for evaluation making the feedback more "forgiving" for specific types of errors during a period, so the system should allow for an adaptable priority set by the teacher for each student ("Teacher's palette") including:

- A number of fixed settings related to age
- Personal settings for each student.

Teachers have modelled a profiling mechanism for VEMUS System in order to adapt priority lists to each student's skill level and personal character: The VEMUS Music School House would have 4 – 5 floors. The students proceed through 4 – 5 skill levels during the period 9 – 14 (15) years, each level corresponding to a floor in the house.

Educational Content

Include to VEMUS content the basics of how sound is produced correctly in wind instruments and the possibility to visualize how different blows/or tongue positions affect the attack.

8.2. Use Case: Tuning-Up

Actors & Context

A student or any VEMUS user. The student interacts with a musical score using the VEMUS environment.

Summary

This educational scenario discusses VEMUS components that support a set of preparatory exercises associated with **a) production of sound and b) production of accurate intonation. The exercises are arranged in different levels of difficulty, according to the ability of each student.** The exercises are supported by diagrams that illustrate issues such as the **coverage of embouchure, direction of air stream, flow of wind et al.**

Description

The production of sound is a complex concept which holds prime importance for all wind instruments. It relates both to embouchure and to the control of airflow. Skilled players can play in tune and produce good sound by using the embouchure alone. By relaxing or stiffening the embouchure they can raise or lower the pitch of a note. Another ability that is particularly useful to wind players in order to play in tune is to “buzz” the melody they are going to play. In order this to happen successfully young learners need to learn to sing through their instruments while playing, in other words to learn to tune their playing with their ears rather than their eyes. To develop accurate intonation, students need considerable experience listening to correctly tuned musical stimuli.

Opening a score:

The student loads a song following the procedure described in the “practicing with a score” scenario (scenario of use A.2). The system displays the score on the screen and the student can then switch-on the “tuning up” option.

Tuning-up:

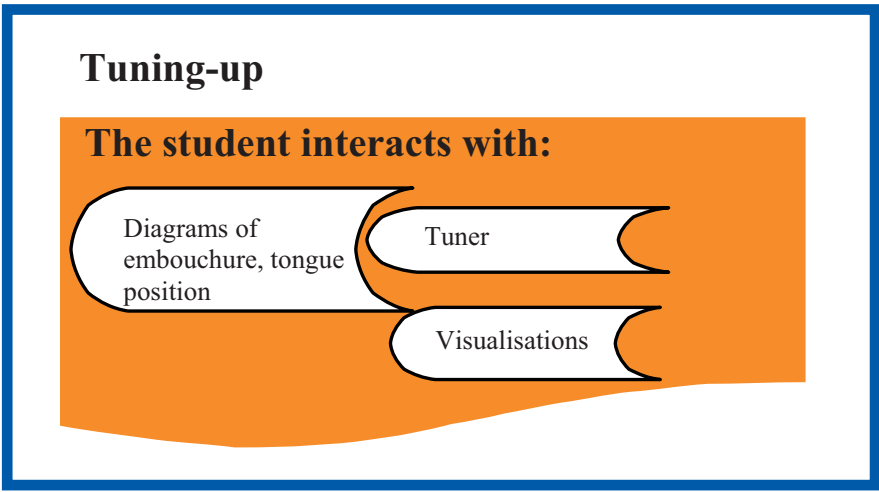
The student plays the tone of the melody (reference note) trying to match the produced sound with the calibrations of the tuner. If the student finds it necessary he/she may switch on the **visualisations** that explain how the production of sound is achieved.

Tuning to a lasting note (tenuta) is the first step of improving tonal intonation. However, a single note lacks context and meaning. As soon as the student manages to get tuned to a single note he/she may **choose exercises that include graded melodies with (1) no motion, (2) step motion, (3) small leaps, and (4) large leaps.** However, the repertoire of the first years of tuition consists mostly of melodies that move by small steps rather than by leaps. Tuning-up exercises should therefore pace with the musical piece that the student is about to learn to play.

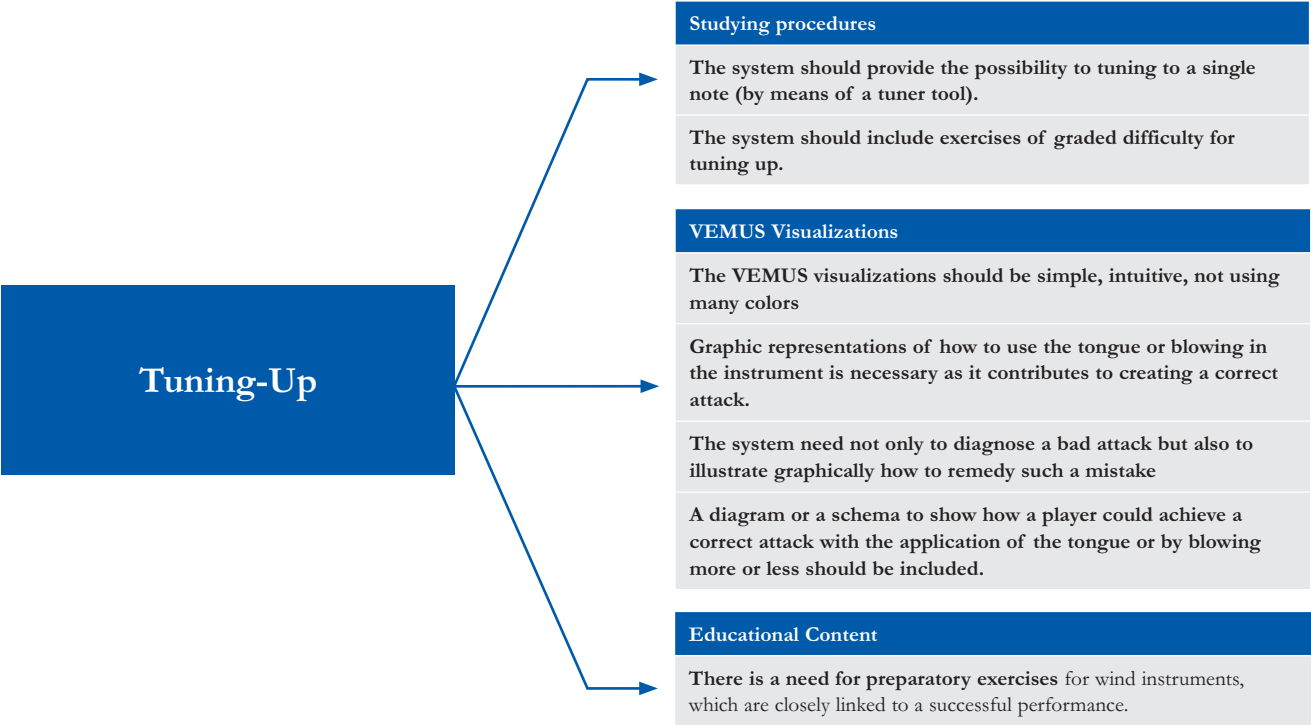
Getting system's feedback:

The system displays **performance visualizations** as part of the system's feedback after the end of student's performance. However in tuning-up the system helps the student to get tuned by showing any tone deviations on **real-time visualizations.** Thus the student may adjust his/her tuning at any point of his/her performance. These visualizations may resemble to the needle of a tuning meter. Typically the note is in tune when the needle sits straight up, and flat when it's to the left of centre, sharp to the right. However, it may

confuse the novice learner really and, as a few cents (or Hz) either way isn't going to be noticeable, relative tuning is certainly more important. Thus a suggested visualization for tuning up is the following:



Summary of use case functions



8.3. Use Case: Teacher introduces a New Musical Piece in the classroom (one-to-one tuition, classroom)

Actors & Context

- A teacher and a student in a one-to-one music classroom. They share a computer.
- A teacher and a number of students in a music classroom. Each student uses his/her own computer.

Summary

The teacher introduces a new musical piece. Following **his/her lesson planning**, the teacher uploads the **annotations** assigned to the specific piece. He/she may also exploit VEMUS' **performance visualization** abilities to **explain hard-to-teach points** and to create **links between classroom teaching experience and self-practicing at home**.

Description

The teacher opens the musical score and introduces a new music piece in the classroom. The score is automatically loaded in all students' computers. The teacher starts playing the piece. He/she may repeat parts of the score and pause to make explanations as necessary, using the VEMUS score as if it were a paper-based music book. In order to annotate quickly the score as he/she introduces hard-to-teach points the teacher uses several emoticons, icons, handwritten symbols and short text sentences. These are easy to add from a special **tools palette**. The teacher discusses some parts of the piece and **makes handwritten notes and visible annotations** on the electronic music score. These annotations can be either pre-made (during the lesson planning of the piece) or made in the classroom (the teacher stops playing to annotate something important or he makes his remarks after finishing his/her performance). They can be general notes on the piece or notes on specific points that require special attention (e.g. points with difficult fingering transitions, additional breathing marks etc).

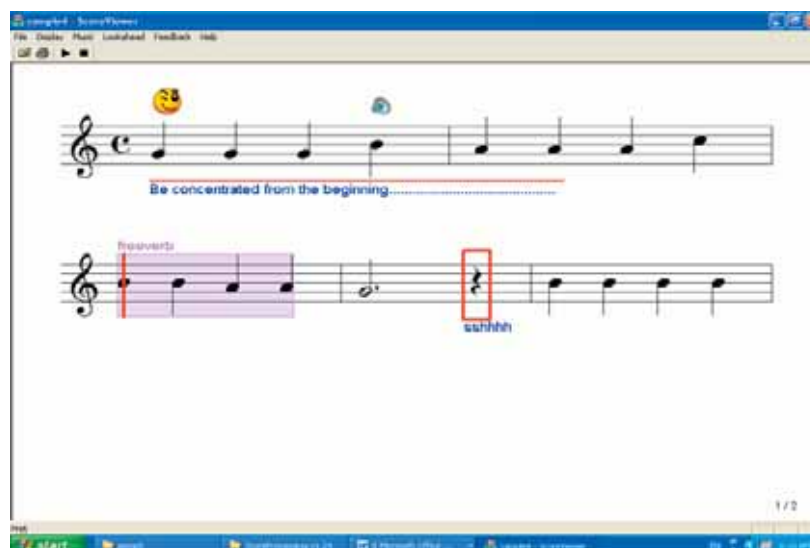
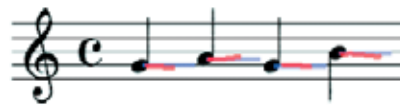


Figure 13: Annotated music score

Visualisations can offer a much more intuitive means for communicating about music and for expressing musical concepts.

These are intended as a means to help the students better understand their performances and their errors and gain a better insight on how to play and how to improve. However, teacher and student need to invest time and effort in integrating visualisations in their practice. The student should be able to understand what the visualisation represents. At this early stage of getting acquainted with a score, teacher may choose to switch on visualizations that address tuning up and correct intonation. A plausible visualization of pitch is the following (displayed on the score):



and a plausible visualization of correct tuning is the following (displayed below the score):

+deviation (on Hz)



correct tuning



- deviation (on Hz)



If the teacher decides to introduce visualizations he/she should be very careful in introducing the suitable ones for a) the musical piece in question and b) the age and levels of his/her student(s). After choosing the appropriate visualizations he/she may check student's understanding of visualizations with exercises, such as the one illustrated below:

Here is a music score:

Here is a graphic

Here are sound records:

A

B

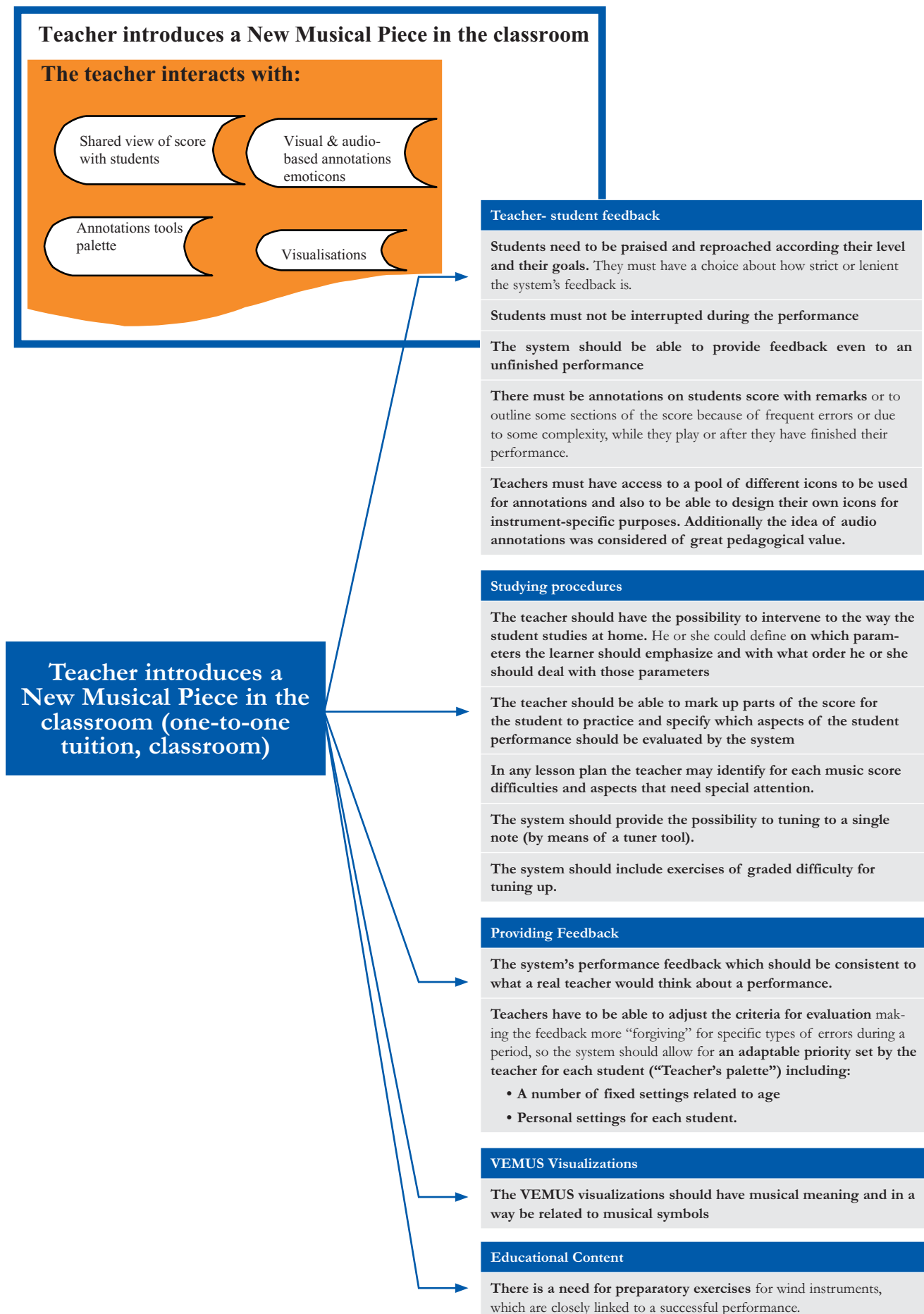
Associate a sound with the curve

☐ A ☐ B

Next

Figure 14: Possible exercise on familiarising students with visualisations: “Choose the sound you think correspond better to the visualisation”

Summary of use case functions



8.4. Use Case: Lesson Planning

Actors & Context

- A teacher before instrumental lesson
- A teacher and a student/a number of students in a music classroom. Each student uses his/her own computer.

Summary

The teacher plans his/her lesson according to student's profile and to the specific task (i.e. musical piece) and uploads all relevant material. In the classroom he/she opens the musical score and follows his planning. At the end of the lesson he uploads all necessary remarks and the studying procedure to be followed by the student(s) in self-practice.

Description

Preparation before classroom teaching

The teacher opens the VEMUS system and checks student's profile and progress: **student's level** (as she is assigned to the VEMUS music school Hsouse), student's record of the **monitored performance and progress** (see Use Case Guided Self-Practice) and PEM's feedback. He/she then finds and **uploads** (if not already existed) **the content and the additional exercises** that can be combined with the chosen musical piece. These exercises may focus on:

- tuning
- breathing
- sight-reading
- technical difficulties (such as fingering, articulation, et al)

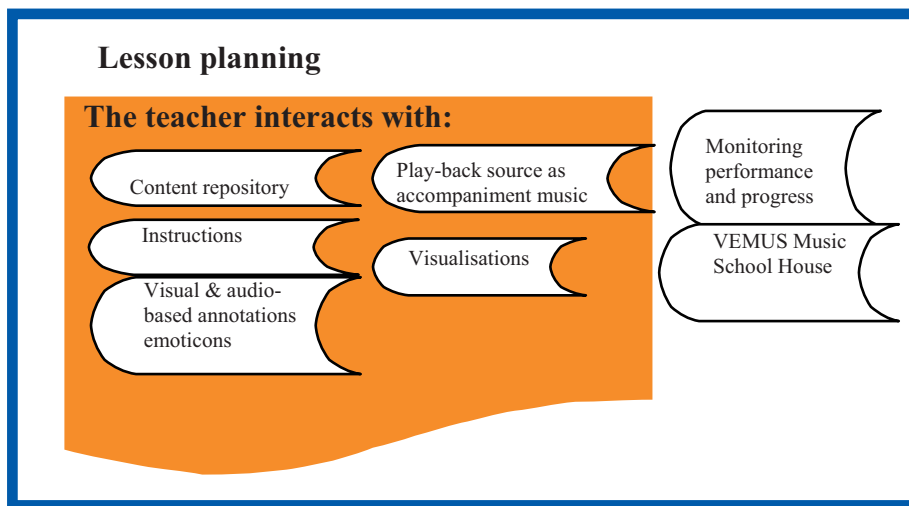
The next step for the teacher is to **find and upload** (if necessary) **additional material that supports the teaching of the chosen musical piece**. Such material may be *historical information* about the composer, the known performances of the piece et al, *diagrams* that illustrate embouchure, air flow et al, or existed *reference performance* of the piece.

If no **reference performance** exists he/she may choose to **record his/her own performance**. Finally he/she uploads the relevant **annotations and visualisations**. He/she then uploads his/her lesson plan with specific steps he/she is to follow in the classroom:

Instructions		
Step	Task	
1	Load the "Merry Melody" song and practice the dotted rhythm, as in the green line box annotated with 'Breath'	
1	Listen to reference performance for the 'Merry melody' piece	
1	Play the piece with annotations on	
2	Practice on <Part A> focusing on <Airflow> until getting <4 stars>	
2	Practice on <Part A> with accompanying music on	
3	Put your emoticons where you feel appropriate	
4	Play whole piece without metronome	
4	Play whole piece with accompanying music	
5	Play whole piece until getting <4 stars>.	
6	Record your best performance	

In the classroom

The teacher opens the musical piece with all uploaded material and proceeds to his/her teaching according to his/her lesson plan (**annotations, visualisations for hard-to-teach points**). Classroom teaching proceeds as described in the Use Case “Teacher introduces a new musical piece in the classroom”. At the end of the lesson the teacher uploads all additional material, such as annotations and visualizations made extra in the classroom. He/she then explains how the student(s) will practice the piece at home following the Instructions. At this point the teacher may also choose to modify **PEM’s** feedback and assign a different level of **VEMUS music school house**.

Summary of use case functions

Lesson planning

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graph LR
    LP[Lesson planning] --> TSF[Teacher-student feedback]
    LP --> SP[Studying procedures]
    LP --> PF[Providing Feedback]
    LP --> VV[VEMUS Visualizations]
    LP --> EC[Educational Content]
    LP --> F[ ]
  
```

Teacher- student feedback

There must be annotations on students score with remarks or to outline some sections of the score because of frequent errors or due to some complexity, while they play or after they have finished their performance.

Studying procedures

The teacher should be allowed to choose the studying procedure

The teacher should have the possibility to intervene to the way the student studies at home. He or she could define on which parameters the learner should emphasize and with what order he or she should deal with those parameters

In any lesson plan the teacher may identify for each music score difficulties and aspects that need special attention.

Providing Feedback

Teachers have to be able to adjust the criteria for evaluation making the feedback more “forgiving” for specific types of errors during a period, so the system should allow for an adaptable priority set by the teacher for each student (“Teacher’s palette”) including:

- A number of fixed settings related to age
- Personal settings for each student.

VEMUS Visualizations

Graphic representations of how to use the tongue or blowing in the instrument is necessary as it contributes to creating a correct attack.

Educational Content

Teachers should be allowed to choose educational content flexibly, depending on their background, taste and preferences.

The available content should be consisted with the school-based work and to include examples from the world musical literature (known works).

As it is widely accepted by music teachers that assigning exercises and melodies to students depends on the level of the student, the instrument, and the preferences of the student, the organisation of the content according to the VEMUS Music School House seems to be an appropriate way to organise VEMUS content.

There is a need for a content repository for wind instruments teaching allowing storing and retrieving not only melodies and music exercises but also text, images, and video to support the teaching.

The teachers should be able to:

- **insert new content;** either content they produce themselves or content they acquire from other sources
- **re-arrange the content** to meet their the requirements of their own classes or schools and/or to meet their own personal teaching preferences

8.5. Use Case: Playing together in the classroom (one-to-one or one-to many students)

Actors & Context

- A teacher and a student in a one-to-one music tuition environment.
- A teacher and a number of students in a music classroom environment.

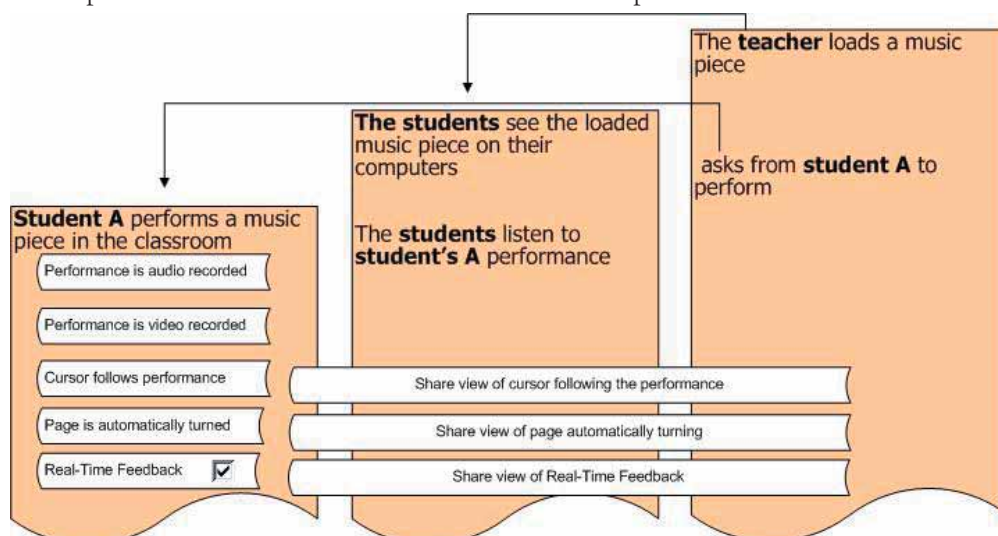
The student(s) interacts with a musical score using the VEMUS environment at his/her computer.

Summary

This educational scenario discusses VEMUS option of “**accompanying music**” and the available configuration tools that had been already introduced (see use case: Teacher introduces a new musical piece in the classroom). This scenario exploits the system’s possibility to provide a **reference performance** for the student and creates links between the different settings that the term “music classroom” encompasses. Accompanying music may be either MIDI or AUDIO and is particularly useful for musical pieces from the chamber music repertoire, i.e. sonatas for a wind instrument and piano, trios, quartets etc. (This learning scenario is rather exploratory and need careful consideration with regards synchronization. The scenario creates complex exchanges when more that 2 students are involved).

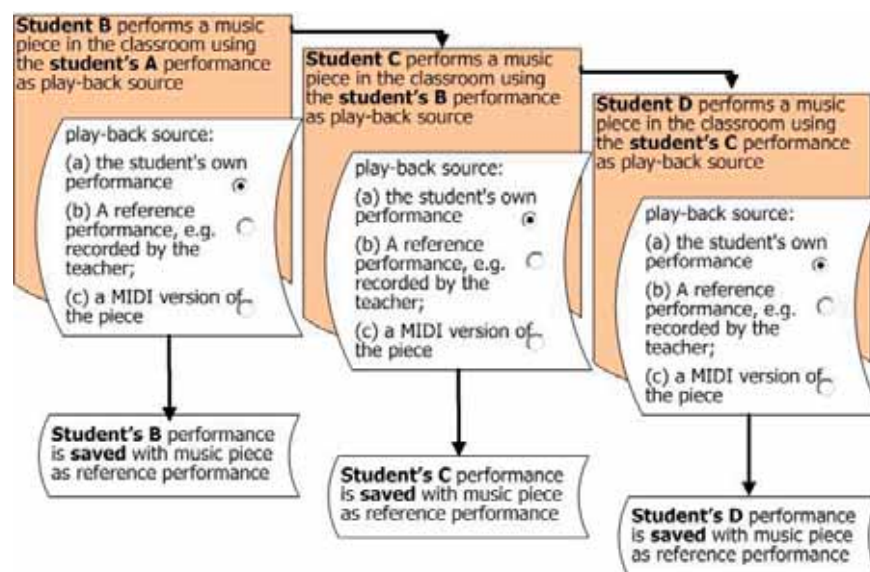
Description

In this setting the teacher may benefit both from the number of students and the different instruments played by them and create, by the means of VEMUS, a learning resource with recorded pieces from band or other chamber music repertoire. This is particular useful in band music lessons as, by splitting the class into groups, it may help the teacher to better organize his/her lesson which usually has both limited duration and students that vary in level and proficiency. The aim is to create a reference performance for another student who belongs to the same band of chamber music ensemble. The performers should see this experience as a rehearsal where mistakes are acceptable. The scenario builds on the



“Teacher introduces a new musical piece in the classroom” and follows the same first steps as described in section 8.3. As the main aim is to record a performance and pass it to another student, students are encouraged to perform whole pieces without breaking it in parts.

At the end of student's A performance (Performance A) and following teacher's feedback the teacher may choose another student, Student B, who either plays a different instrument or a different voice of the same piece. The second student imports the previous student's performance and uses the toy-mixer to choose that as his/her accompanying music. He/She then plays on top of Performance A and records his/her own performance (Performance B). The same procedure may be followed in a number of performances (Performance C, Performance D...).



At the end of performances each student will automatically have stored in his/her computer all reference performances together. Thus the students will gain a fairly good idea of how the practicing piece really sounds when played by them and not just from a pre-recorded accompanying music. At the same time the system keeps a record of performances and progress for each student.

Playing together in the classroom

The student interacts with:

Play-back source as accompaniment music

Getting feedback from the system

Monitoring performance and progress

Playing together in the classroom

Teacher- student feedback

Students need to be praised and reproached according their level and their goals. They must have a choice about how strict or lenient the system's feedback is.

Students must not be interrupted during the performance

The system should be able to provide feedback even to an unfinished performance

There must be annotations on students score with remarks or to outline some sections of the score because of frequent errors or due to some complexity, while they play or after they have finished their performance.

Teachers must have access to a pool of different icons to be used for annotations and also to be able to design their own icons for instrument-specific purposes. Additionally the idea of audio annotations was considered of great pedagogical value.

Accompanying music

Accompanying music, either as playing together or playing in turns, is considered important in music learning for many reasons: it helps the students keep up with the rhythm, it increases the motivation, interest and encouragement, it fosters the ability to continue playing despite difficulties to complete a performance to the end.

Studying procedures

The system will need to keep a record of performances for future reference and for monitoring the pupil's progress and to generate a progress report based on a) the performance skills category, b) Student's recorded performance evaluation and c) Student's devoted time on task

At the end of the studying procedure it is important for the student to join the parts of the piece together in order to have the feel of the whole piece.

Providing Feedback

The system's performance feedback which should be consistent to what a real teacher would think about a performance.

Teachers have to be able to adjust the criteria for evaluation making the feedback more "forgiving" for specific types of errors during a period, so the system should allow for an adaptable priority set by the teacher for each student ("Teacher's palette") including:

- A number of fixed settings related to age
- Personal settings for each student.

Educational Content

Include to VEMUS content the basics of how sound is produced correctly in wind instruments and the possibility to visualize how different blows/or tongue positions affect the attack.

There is a need for preparatory exercises for wind instruments, which are closely linked to a successful performance.

Teachers should be allowed to choose educational content flexibly, depending on their background, taste and preferences.

The available content should be consisted with the school-based work and to include examples from the world musical literature (known works).

As it is widely accepted by music teachers that assigning exercises and melodies to students depends on the level of the student, the instrument, and the preferences of the student, the organisation of the content according to the VEMUS Music School House seems to be an appropriate way to organise VEMUS content.

There is a need for a content repository for wind instruments teaching allowing storing and retrieving not only melodies and music exercises but also text, images, and video to support the teaching.

8.6. Use Case: Playing together over distance

Actors & Context

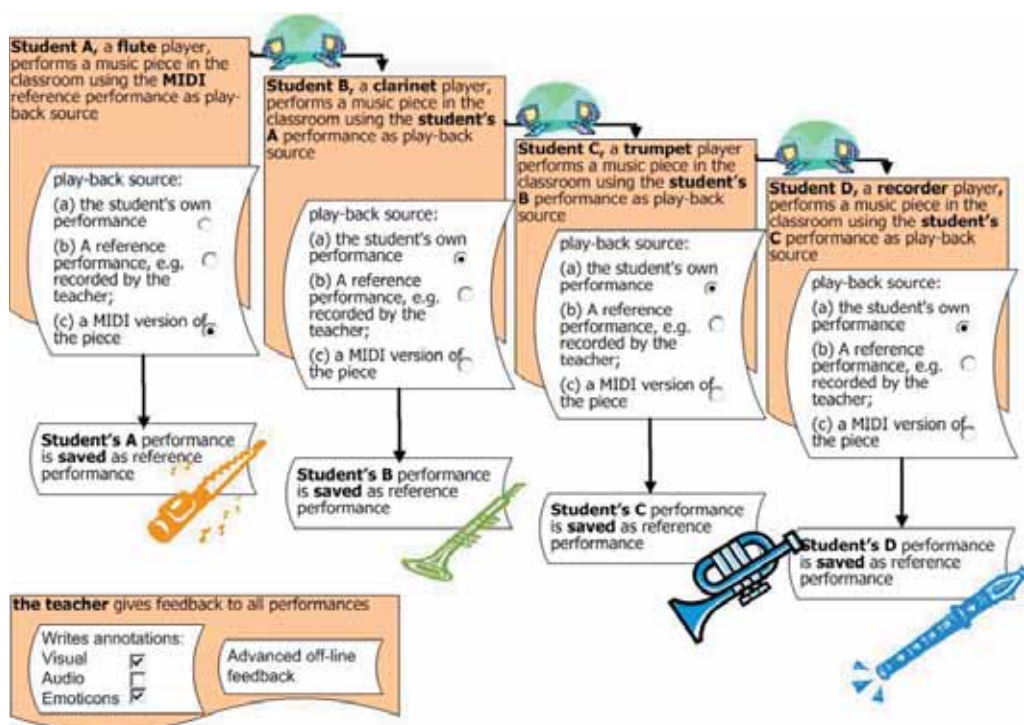
More than one students of the same teacher working in distant locations.

Summary

This scenario exploits the system's possibility to provide reference performance to many students in a chain, similarly as in the playing together in the classroom use case. Recorded reference performances are exchanged between students who are based on various and distant locations.

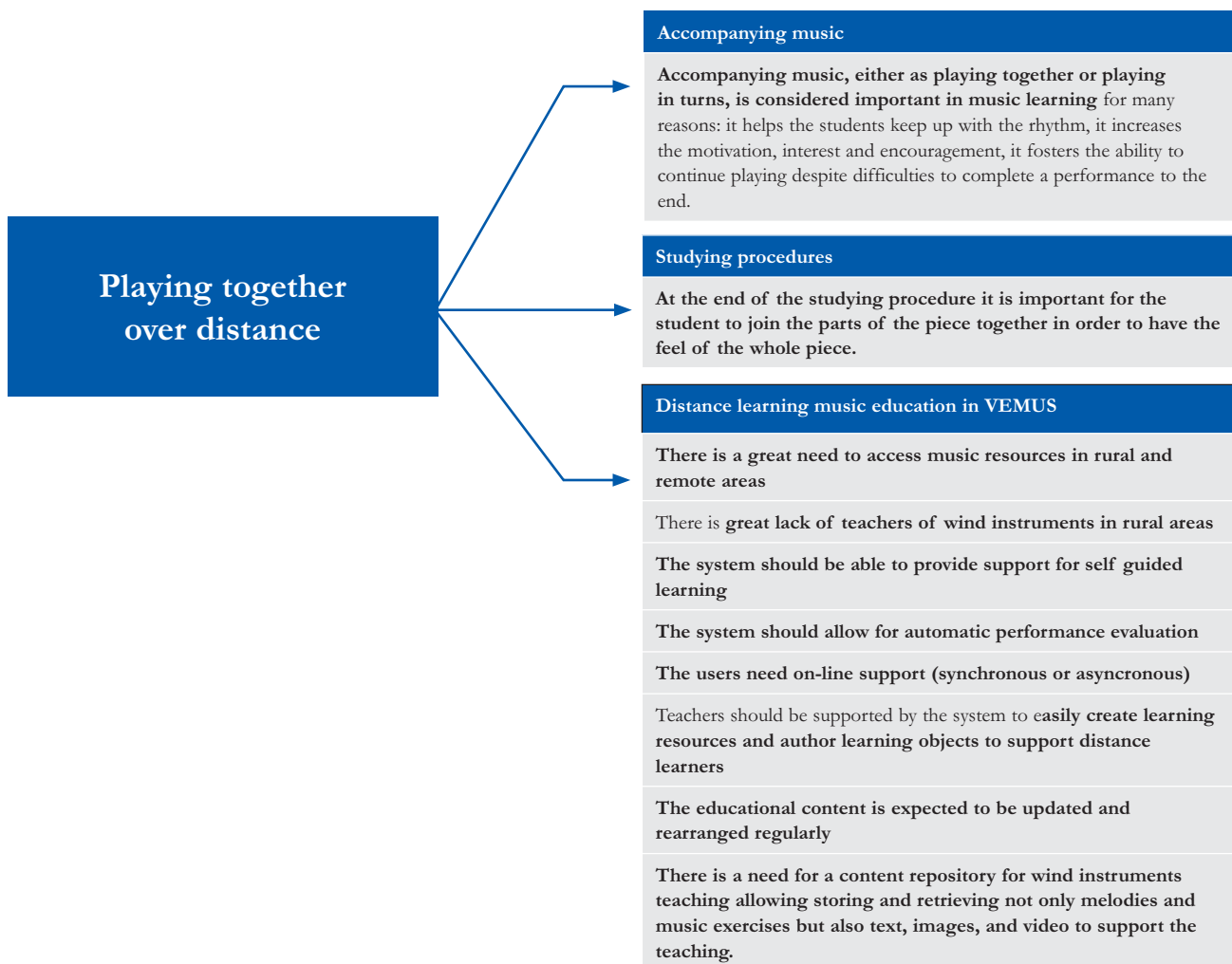
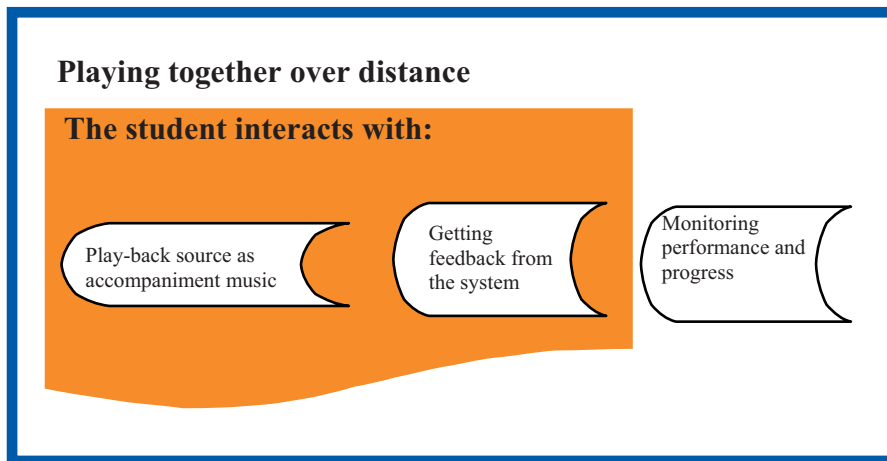
Description

This scenario may be very useful in such cases as having two or more remote students that work and study separately using VEMUS. Such a joint project may be part of a real educational setting when two or more students learn to play together a music piece (for example in the case of a philharmonic (band) orchestra that engages students who see each other only once a week and have to perform frequently a diverse repertoire). Additionally this case can be implemented in cases where two remote classrooms are working together (see the example that follows the use case description).



At the end of the series of performances, all reference performances together with the teacher's feedback (handwritten notes, recorded oral comments, shapes) are stored in the student's computer. Thus the students will gain a fairly good idea of how the practicing piece really sounds when played by them and not just from a pre-recorded accompanying music. They will also have the teacher's comments on how and **what to take notice when practicing alone**. This can be achieved by following a given **Instruction list**. A proposed scenario for an in eTwinning project between two remote schools is presented in the following.

Summary of use case functions



Twinning Music Schools through Technology

Note: eTwinning (www.etwinning.net) is a framework for schools to collaborate on the Internet with partner schools in other European countries. eTwinning is part of the European Commission's eLearning programme. The scenario that is presented in this session has been prepared by members of the VEMUS consortium in cooperation with the eTwinning Hellenic National Support Service in the framework of the eTwinning Professional Development Workshop "Arts and Humanities", (www.etwinning.gr/DW_Athens/) held in Athens (April, 6-8 2006).

Short Description of the proposed eTwinning project

The purpose of this project is to twin two remote music classrooms. Through the mediation of their teachers the students of the two classes communicate, prepare and exchange musical material and traditional songs, study traditional songs from other countries, make musical performances in front of their peers and exchange comments and feedback.

Age Group / Level

Students of beginning to intermediate level in music, who are usually in the age of 9-14 years old. Students should be able to read and work with music scores. However, students of any other age should be able to participate.

Duration

2-3 months.

Cooperation Model

Teachers with groups of students.

Subject

Music teaching, traditional music.

Cooperation Language

English or any other mutually agreed language.

Very few text documents are produced or exchanged (mainly material accompanying the songs) so there are no major restrictions posed by the educational content. The communication of the two groups is mediated by the two teachers in a language that best suits them.

Cooperation Tools

- teleconferencing (for classroom communication), e.g. Skype or NetMeeting;
- email (for asynchronous communication and exchanging of material);
- simple tools for creating and maintaining a website;
- simple music editor (for creating music scores electronic format);
- VEMUS prototype (for practicing music).

Cooperation Procedure

1. Preparation

Preliminary Communication: The two teachers get in contact to agree on the general lines

and objectives of their cooperation, to discuss on the level of the two classes, and to set-up a communication schedule (specific days and frequency of class contacts).

The teachers then establish the criteria for selecting the music pieces to be exchanged. The tunes should be traditional (folk) songs from each of the two countries (“family tunes”). The selection criteria could be based on:

- how representative a song is for the country’s traditional music;
- how popular the song is in its country and abroad;
- what cultural and/or historical facts are associated with the song; and
- the difficulty level of the song in order to make sure that it is appropriate for the level of their students.

Depending on the cooperation period, seasonal songs could also be favoured (e.g. near Christmas). Finally, the two teachers discuss on the specific tools to be used during their cooperation. These mainly include:

- A simple music notation editor that will be used to prepare the music scores in electronic format. Any commercial, shareware, or freeware music editor that may be available could be used.
- The VEMUS prototype that the students will use for practicing at home or in the school’s music room or laboratory

Initial Selection of Songs: Based on the agreed criteria, each teacher makes a first selection of representative songs from her/his own country, e.g. 6 songs. The songs may be selected from the normal curriculum of the class and are preferably songs that the students have already studied. This will enable the students in the teacher’s class to closer follow the progress of the students of the other class.

Internal Introductory Session at Each Class: Each teacher presents to his/her class the eTwinning project and explains the rationale, its value and the expected outcomes to the students.

The teacher then presents the initial list of song to the students and they discuss about each. The students are then asked to vote for the songs they prefer, making the final list of e.g. 3 songs.

Then, for each of the songs, the teacher assigns a student that will perform it and a team of 2-3 students that will collect some material related to it. He/she also provides a time frame (e.g. about 1 week).

2. Content Preparation

All material collected by the students for each song is assembled into “learning units”. One “learning unit” corresponds to one song and comprises of:

- the music score in electronic format, produced using the agreed music editor
- a reference performance of the song, recorded by the teacher or a student
- some comments and notes on the piece and its history, cultural value etc.

- some electronic annotations on the music score marking difficult parts or drawing attention to points that require special attention

All this material is packed into a learning unit using tool from the VEMUS prototype. The preparation of the content in electronic format could be performed by the teachers or be assigned to students. In the later case, the teachers need to:

- Make the music editor software available to the students, e.g. at the school's computer room or laboratory
- Provide help to the students on how to use the software, e.g. arrange an introductory session and circulate some simple user's manual

All the produced content is uploaded to a website specially developed for the project by the students using simple website development tools.

3. First Virtual Meeting

At a specified time, the two classes get in contact through teleconferencing and the students are introduced to each other. The overall process and communication is mediated by the two teachers.

Each teacher presents the songs selected by his/her class to the students of the other class, also making reference to their history and/or cultural background. For each song, the assigned student performs it live to the students of the other class.

The two classes then exchange the associated learning units they have prepared and make plans for their next meeting (e.g. in 1-2 week).

The teleconference is terminated. Then, each teacher assigns the received songs to his/her own students. The students can choose themselves which one they prefer to learn or this choice can be left with the teacher.

4. Students' Work Between Virtual Meetings

In the time between the teleconferences, the students work on their assigned songs, in parallel to their regular curriculum. To avoid any interference with their regular curriculum, the students mainly study at home or at the school laboratory at their spare time with the support of the VEMUS prototype. Of course, they can also request for some help from their teachers. The VEMUS prototype can store the performances they make at home so that they can later share them with the student to obtain some feedback and instructions from him/her.

5. Subsequent Virtual Meeting

A pre-agreed number of virtual meetings among the two classes then follow, using teleconferencing. At each meeting, the teacher chooses which student will perform each of the assigned songs. It is not necessary for the students to have perfected their performances on the songs. The main purpose of the meeting is for students of the two classes to perform in front of each other and receive comments and feedback on their performances. So, each of the selected students from each class perform their song. At the end of each performance, the students of the other class are requested to provide comments and specific suggestions. They provide comments in free form and these are

conveyed through the mediation of the two teachers.

Alternative: Performing in front of unfamiliar people may put a lot of stress to some students. In that case, for some of the meetings a pre-recorded performance of a student could be used instead of a live performance. However, teachers should try to help students overcome this hesitation and feel more comfortable in performing in front of an audience.

6. Final Virtual Meeting / Closure

The last teleconference follows the lines of all the previous ones. However, at the end of the procedure, the teachers could have agreed on a special “event”. For example, this could be the nomination of the “best participating student” from each class: students of the one class vote for the “best participating student” of the other class.

This title could be accompanied by a simple agreed reward, for example:

- a special reference in the project’s website to the “best students” of the two classes
- a present, such as a book with a selection of music scores from each country

Related Events

The two teachers could investigate the possibility of organizing a real face-to-face meeting of the two classes as their final meeting. During that meeting the students perform live in front of each other and exchange experiences.

Benefits for the Students

A set of important benefits result from the proposed collaboration project for the students involved. The students:

- get in contact with musical and cultural elements from other countries
- learn how to use technological aids that can improve his/her practicing
- get to feel more comfortable about playing in front of an audience
- are involved in observing and commenting musical performances from other students and receive feedback from their peers
- learn how to use computer music tools such as a simple music editor to write music



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Appendix I

IntQ1

[I. Practical teaching issues]

Basic issues related to teaching practices are:

how to handle possible cultural differences among the different countries, and
how the student builds trust in VEMUS.

With regards to the evaluation of attacks it has been pointed out that an issue may be raised between different countries, which presumably follow different schools of music. The differences between schools may affect the way evaluation is carried out. These differences may be related to language pronunciation and even the shape of the mouth palate. In VEMUS, however, the evaluation of attacks should be kept on a manageable level, in other words simple. In any case, the role of the teacher is always more important than the software.

Though cultural differences in teaching practices may well exist between countries, it is planned in VEMUS to design one common strategy for the performance evaluation, and it is essential that it shares the common elements.

Q1. Is teaching emphasis placed on short exercises or simple melodies according to: a) each country, b) each instrument, c) each student's level?

In Sweden the students typically proceed through 3 schools during 5 years. Additional melodies and exercises are used according to the needs of the student to practice more on certain difficulties. This material is distributed by the teacher as sheet music.

Keywords: Structure of educational content

IntQ2

Q2. How often does the teacher play together with the student (the same instrument or piano)?

Keywords: accompanying music, a music piece as a whole complete performance

IntQ3

Q3. When and how do teachers comment on students' performance? Do they interrupt their students in order to correct them?

Swedish teachers do generally not interrupt young students while playing to correct or give feedback. The student is allowed to play the piece to the end. Further, the teacher generally encourages the young student by giving praise as soon as there is a possibility. The basic concept is that it should be fun to play, rather than a strict education with the possible aim of a professional career.

IntQ4

[II. Studying procedures]

All teachers give guidelines to their students on how to practice at home. For example, a common advice to learners on studying practice is:

“Start from simply playing the notes, i.e. mainly study the fingering and the notes...we will deal with more difficult things such as how to breath and use the tongue in the lesson.”

The aim is to help the student to start and finish playing a score despite the difficulties and the errors.

Q4. Teachers give feedback on various aspects of students' performance, such as fingering, pitch, articulation, sound quality. Vemus system should be able to evaluate the performance in accordance to student's proficiency? Please comment on the prioritization of the feedback.

IntQ5

Q5. What is in your opinion the basic concept of the studying procedure and the steps that students should follow during self- practicing?.

An example of such concept could be:

1st module: Practicing attacks, the learner is playing long notes (τενούτα). The learner receives feedback from the system, on the basis of the waveform, in a similar way as when he plays the whole melody.

2nd module: The learner plays a few notes together, e.g. one measure, and practices difficult fingering. (It was noted that the same notes may be played much more easier by some instruments than by some others. The structure of the keys on the instrument and the shape of the instrument may affect the difficulty of fingering).

3rd module: The learner is playing the whole score. The skills the learner acquired from the previous modules are integrated in this module. He or she receives feedback as in IMUTUS.

Finally, if the learner receives satisfactory feedback he or she can proceed to another set

of modules. There may also exist an additional module or separate option for each of the three modules:

4th module: The learner could play the notes or melody with accompanying music, e.g. piano. Technically that is possible using headphones.

IntQ6

[III. Educational content]

Large differences are expected in the curricula or 'schools' (printed books with teaching material) among the different countries. Other differences affecting the educational content and its structure, relate to different teaching styles.

Q6. In which order do we introduce musical notation in a) every country b) every instrument?

[V. Repertoire]

Q7. Please collect a sequence of popular melodies in Greek instrumental tuition.

IntQ8

[V. Visualisations]

I was acknowledged that there is a need not only to diagnose a bad attack but also to illustrate graphically how to remedy such a mistake. One of the teachers proposed to have a diagram or a schema to show how a player could achieve a correct attack with the application of the tongue or by blowing more or less. Existing methods (e.g. books etc) may give some insight as to how to prepare such diagrams. For the trumpet we have some material already, for example see the following example:

Q8. What is your opinion Do you think Vemus system should include visualizations on breathing control, mask, instrument's grip, et al?

IntQ9

[V. Structure of educational content]

It is envisaged that the content would be organized in lessons and chapters following an order of incremental difficulty.

Q9. What difficulties do you think that a music teacher would face concerning the update and revision of the content?

IntQ10

[Elements to be Evaluated in a Performance]

The music teachers in the six VEMUS countries should agree on elements in the performance which should be judged and the priority between these elements. Typical examples of elements of the performance that all teachers probably agree on that they should be included in VEMUS performance evaluation are [WS3, pg. 1]:

Q10: Is there a full agreement on these elements in the performance which should be judged?

Attacks,
rhythmic errors,
melodic errors,
control of air flow, and
fingering technique

The question is rather the priority between them and how this priority changes as the student progresses.

IntQ11

[Displaying Evaluation Results to the Student]

In the Stockholm workshop the Swedish teachers agreed to retain the basics of the IMUTUS evaluation concept :

Give an overall grading with 1 to 5 stars. The grading is based on the total number of detected errors in relation to the number of notes in the piece. It should be easier to get more stars with the 'kind' type of VEMUS teacher.

Show the 3 most important errors/mistakes hidden behind buttons (4 errors for the 'strict' teacher). The percentage of positive comments should vary between the three types of VEMUS 'teachers': roughly 25% (1 pos. every fourth comment) for the 'kind' teacher, 15% for the 'medium,' and 10% for the 'strict' teacher.

However, they reduced number of mistakes was considered as a drawback.

The feedback is given as a text message and high-lighted note/bar(s) to show the location of the error.

However, it was considered as a drawback that the performance evaluation was only provided in the form of a text, without displaying the deficiencies by elements of musical notations. It was suggested [WS2, pg. 2] to mark the sound by another color and to make visible the correction by signs when a performer makes a mistake, for instance (this is similar to the real-time feedback of InTheChair):

upward /downward arrows for pitch
left-right arrows for tempo
note values for rhythm, etc.

Two levels of help are considered sufficient ('get hint,' 'get help')

Graphical visualisation of student performance and of reference performances will also be considered in VEMUS.

Q11. According to Imutus, the system gives a general evaluation of a performance ranging from one to five stars. The system shows the three more important mistakes hidden behind buttons (4 mistakes for the strict teacher). It was also suggested that music typology should be given instead of text. Two levels of help are sufficient (get hint, get help). Comment on the above statements

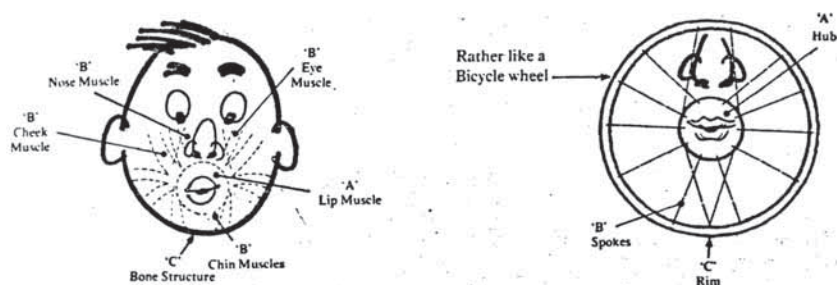


Appendix II

Material brought by teachers of wind instruments on generating sound with the mouth during interviews

I use the following analogy:

EMBOUCHURE (‘CHOPS’)



- A) Lip Muscle/Hub — Hold firm with corners locked in position.
- B) Check, Chin, Eye & Nose Muscles/Spokes — Pull away from the lip muscle and join the bone structure.
- C) Bone Structure/Rim — To which the spokes are attached.

The Spokes have to be tightened equally —

(Ask your teacher to help you look like ‘GREAT CHOPS’)



‘GREAT-CHOPS’

Otherwise Your Wheel Will Buckle



‘BUNCH-CHOPS’



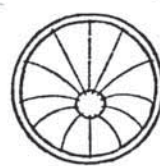
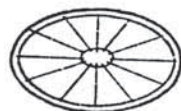
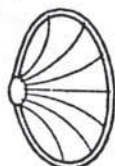
‘SMILEY-CHOPS’



‘PUFFER-CHOPS’



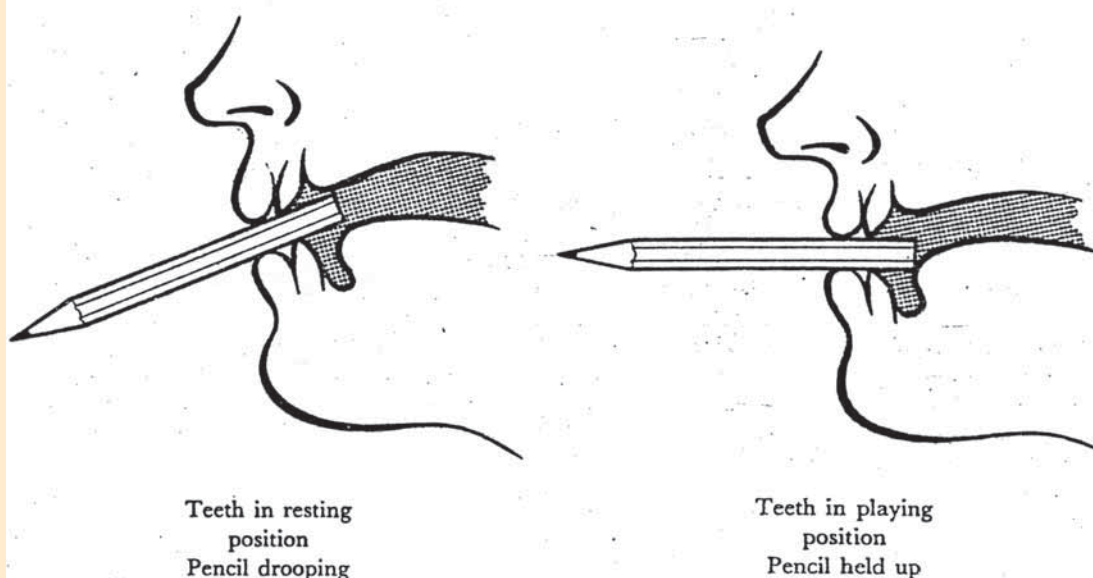
‘DROOPY-CHOPS’



John Ridgeon, ‘New Horizons for the Young Brass Player’. Brasswind Pub.

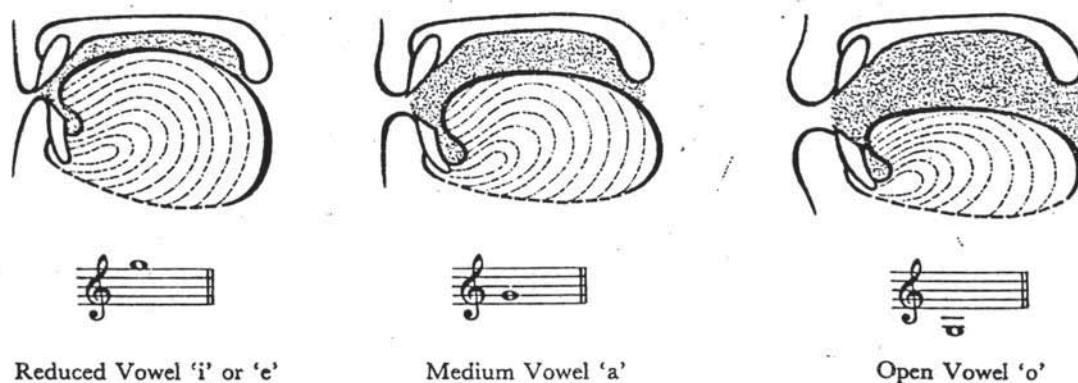
I think that it is a matter for concern if a teacher does not offer specific advice to a student on the setting of the lower jaw. In my experience, the majority of embouchure faults arise as a direct result of the jaw remaining in its passive position. The image of "shaving the chin" or "spreading lipstick on the lower lip" will often help to combine the forward jaw position with the desired texture of lip and chin.

As an alternative try the following:



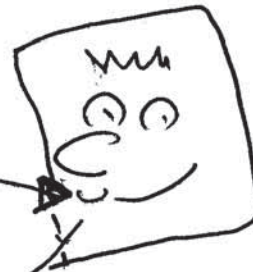
It was apparent from performers that the forward jaw position once established was by no means inflexible. The horizontal position was constantly being adjusted in response to pitch. This does not mean that the jaw retreats to the passive masticating position for certain notes. It simply means that the jaw moves between certain personal parameters to provide the appropriate structure on which the lip tissue can most effectively function. It is found by most players that when tongue movement is combined with the vertical and horizontal jaw movements an easy flexibility is achieved.

The following diagrams show that the combination of vertical and horizontal movement causes the lower jaw to travel in a diagonal projection. This helps ease the embouchure into an appropriate position for the required notes. This will be discussed in detail in Chapter 5.



breath-in quickly
in a relaxed way

δριζορη
χαλαρή
είσοδου.



δριζορη φηνοί χαρτί re
κρατά μέρα να τίρε

breath out quickly without keeping the air inside

1cm πίεση
Equal pressure

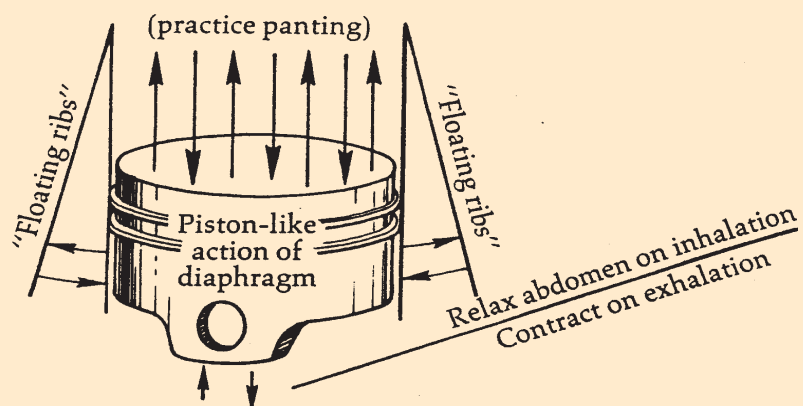


Equal pressure

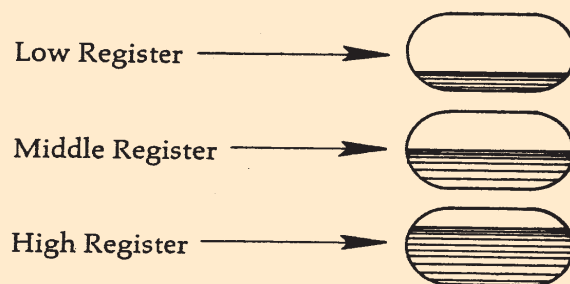
1cm πίεση

FACTORS IN TONE PRODUCTION

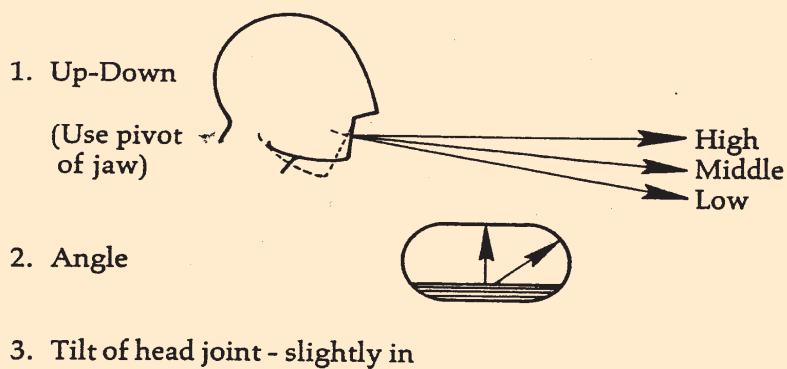
I. Diaphragm



II. Coverage of Embouchure Hole

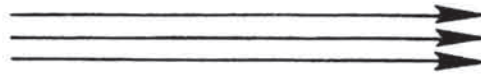


III. Direction of Air Stream



III. Flow of Wind

1. Amount of wind
(volume)



2. Speed of wind
(intensity)



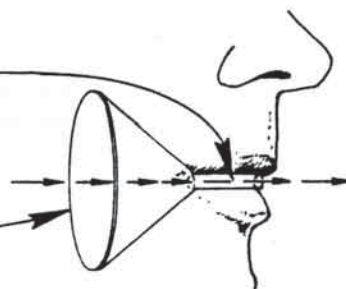
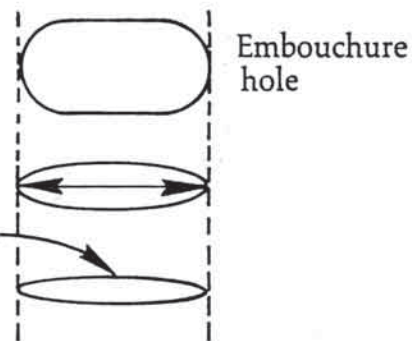
3. Shape of wind

a) width of stream

b) degree of opening
(grip)

c) length of lip tube
(nozzle)

d) shape of mouth
(funnel)



IV. Resonance

1. Mouth, tongue (vowel sounds)

2. Open throat (yawn)

3. Rib cage (extended up & out)

(Like speaker cabinet)

