

1. Project Name and Project Director's Name. Include mailing address, phone and e-mail address

Project Name: *A Digital Self-Tutorial for Piano and Music Study*

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2. Brief Description of Project

Through this research project, interactive instructional music software was developed that facilitates a learner-centered approach to the study of the piano and music. This was accomplished through linking the performance of a musical composition with a graphic representation of the musical score. The graphic representation provides an alternative mode of viewing, listening to, and studying a musical composition and performance. This interactive software allows a learner to directly interact with a musical performance, transforming the routine processes of listening to and analyzing a musical composition into a dynamic, interactive process of learning and fostering more profound student research and discovery. What appears on the surface to be a simple exploration of sounds evolves into the ability to manipulate and listen to the different elements that comprise the music, stimulating problem-based inquiry learning and an interactive music laboratory. Learners are guided to explore the musical graph as they critically listen to and examine the design and musical patterns of a composition. While listening to the musical performance, learners can: isolate and view single or multiple layers of a composition, zoom in or out, play the music from any location, and discover relationships between the graph and the traditional music notation. In addition, the self-tutorial allows each learner to discover the music at his or her own pace according to the level of complexity that the learner chooses as he or she moves through the self-tutorial.

3. Goals, Outcomes and Assessments

a. Goals and Primary Accomplishments

Goal

The goal of this research project was to develop an interactive instructional CD-ROM that would facilitate a learner-centered approach to the study of the piano and music through linking the performance of a musical composition with a graphic representation of the musical score. The final result of this research project was to be a packaged CD-ROM consisting of four (amended from eight in December 2004 Progress Report) intermediate piano compositions to be implemented in the curriculum of the MUS 101A course (*Exploring Music through the Piano for the General Education Student*) at the University of Arizona. In addition, the software could be used in university, secondary, and elementary general music education classrooms or in the applied piano studio.

Primary Accomplishment

One composition (*From Foreign Lands and People* by Robert Schumann) has been completely developed in the prototype and is fully functional. The graphs and audio files of the remaining three compositions are integrated within the software and are functional; their accompanying lessons have been outlined but currently have not been added to the software. A help menu and a glossary of terms are features of the interface and a separate interactive component entitled “About the Piano” guides the learner through interactive screens of the history of the piano.

b. Outcomes/Assessments: Software and CD-ROM

The interactive instructional music software has been developed and its design, functionality, and learning content have far surpassed the original vision and goals of this project. Its improved design is the result of user assessment and feedback as to the usability and interactivity as well as comprehension of the lesson content. Finalization of the software into a CD-ROM is pending the completion of the accompanying lessons for the three remaining compositions.

Stage 1 Goal: Design a Mini-Prototype of One Piano Piece, to be Field Tested and Assessed

- Design of the information architecture for the interface of the software, a learning analysis to identify music learner outcomes, identification of one of the piano compositions as the mini-prototype, February 2004.
- Development of the mini-prototype for integration with the interface, which included recording the composition, extracting and editing the musical layers, and converting MIDI files to audio files, February 2004.
- A “first draft” of the main interface of the mini-prototype, March 1, 2004.
 - Although not functional or integrated with the music, this interface included the static graphic representation of the music, a control panel, and the layout of the music tutorials.
 - Production team evaluated visual language and software application successes and needs.
 - Screens demonstrated to designers and students to obtain feedback on quality and successfulness of graphic designs.
 - Music educators and design experts evaluated issues of usability, procedure, and efficiency.
- Initial testing of the interface for the MUS 101A course, scheduled for March 2004, was rescheduled for fall 2004 because developmental complexities involved a greater amount of time than originally projected.
- Developmental complexities beyond the expertise of Treistman Center necessitated the hiring of an outside expert in Macromedia *Flash* and *Director*, May 2004.
- Refinement of process for recording, editing and extracting the MIDI data of the compositions via Digital Performer™ software (a high-end sequencing and editing program) and the Yamaha Disklavier, May 2004.

- Consultation and evaluation with experts George Litterst (*TimeWarp Technologies*, expert in *Digital Performer*); Dr. Linda Beckman (John Brown University, pianist and specialist in editing and sequencing MIDI data.); Wiley Ross (University of Arizona, recording engineer).
- Conversion of the audio files to a file format compatible with Macromedia *Director*. *Director* was used to create the graphic user interface, allowing the learner to interact with the piano tutorial.

Stage 2 Goal: Use Assessment Data and Develop Remaining Seven Compositions

- A “mock-up” of an audio file with the graphic interface was launched and tested.
 - Consultation with Dr. Bruce Frazier, expert in multimedia design, to assess integrity and coherency between audio files and graphic interface.
- Primary goal of implementing the design process with the remaining seven compositions was not met in June 2004 as projected due to the unforeseen complexities involved in developing a fully functional interface.
 - Final conversion of MIDI files to audio files of prototype composition accomplished in recording studio at University of Arizona, July 2004.
 - Recording of the remaining seven piano compositions completed, July 2004:
 - Johann Sebastian Bach: *Invention in F Major*
 - Ludwig van Beethoven: *Sonatina in F Major*
 - Frédéric Chopin: *Prelude in B Minor*
 - Claude Debussy: *Le petit Nègre*
 - George Frideric Handel: *Gigue in D minor*
 - Wolfgang Amadeus Mozart: *Arietta*
 - Vladimir Rebikov *Evening in the Meadow*
 - Robert Schumann: *From Foreign Lands and People*
 - Notation files of each composition for integration into software created using *Finale*, a music notation program, August 2004.
- *Director* software used to integrate the audio and graphic files created an unacceptable level of instability in the application, July 2004.
 - Research determined that Macromedia’s *Flash* software would more precisely synchronize the audio files creating a better application for the interface.
- Usability testing of prototype, November 2004.
 - Testing at *interface guru*, a usability lab in Tucson that specializes in software interface assessment; fourteen video compilations of individual students interacting with prototype were accomplished using *Morae*, a state-of-the-art usability testing program.
 - Tested and videotaped in groups at Digital Imaging Lab at University of Arizona. Four user groups tested interface: 1) fifty three students presently taking MUS 101A, *Exploring Music through the Piano for the General Education Student*, at

the University of Arizona, 2) four pre-college intermediate piano students, ages nine–seventeen, 3) four graduate teaching assistants who teach piano at the University of Arizona, and 4) two undergraduate pedagogy students.

- Follow-up interviews assessing usability, procedure, and efficiency were conducted at both the *Morae* and Digital Imaging Lab sessions.
 - Received positive feedback from the students in terms of design, clarity, and ease of use.
 - Results compiled from testing of prototype, December 2004.
- Initial goals of project reassessed in terms of time, labor, and budgetary constraints; concluded that original goal of developing eight pieces was beyond the scope of the project; goal amended to four compositions, December 2004.

Stage 3 Goal: Major Revisions And Enhancement Based On Evaluation And Assessment Results

- Major revisions and enhancement and reprogramming of functionality incorporated into the prototype. These were based on student testing, graduate teaching assistants' reviews, and feedback from design experts, January 2005.
- Modifications and refinement of the design and menu structure of the graphic interface, January 2005.
 - Dissolved multiple screens of the tutorial, replacing them with a user interface that allows the learner to access different features of the tutorial directly from menus on one main screen.
- Redesign of original multi-colored interface to a gray-scale color scheme, creating a more sophisticated, user-friendly design, January 2005.
- More precise synchronization of the graph with the audio files, February 2005.
 - The graphic images of the four compositions were completely recreated as xml files. The four graphic representations of compositions had been generated using the graphic program *Illustrator*. It was determined that if these graphic images were rendered as xml files, the time code from the audio files could be precisely synchronized with the number code of the xml files.
- Graph and traditional score synchronized to be played simultaneously, allowing the learner to compare patterns and relationships in each notational system; individual pitches of the traditional score are color coordinated with the colored lines of the graph. Learner also has the ability to toggle between black or colored notes; vertical play-head extended below graph to include the score, February 2005.
- Functionality expanded allowing the learner to play the graph from any point in the composition by four different means: double clicking on a specific measure number; double clicking at any point in the graph; dragging and moving the graph to a selected area; adjusting a horizontal slider bar to the desired area of the graph. Functionality added that allows the learner to hover over any horizontal (pitch) line on the graph and identify name of pitch, January – May 2005.

- Lessons reworked to incorporate the refined functionality of the interface. Over 100 audio files created to embed within lessons to provide greater interactivity so learners are able to compare and contrast different musical events and construe relationships between graph and additional audio files, January – March, 2005.
- Template developed for remaining piano compositions including the file structure for graphic representations and the coding of the lesson content, March – May, 2005.
- Due to these modifications and enhancements, the interface was not ready to be tested in spring 2005; a six-month extension was granted and final testing was accomplished in fall 2005.

b. Outcomes/Assessments: Implementation

- Application tested by students in the Tier Two General Education Course MUS 101A (*Exploring Music through the Piano for the General Education Student*) and MUS 361 (*Music Learning and Perception in the Preadolescent*) at the University of Arizona. In addition, piano pedagogy students and graduate teaching assistants at the University of Arizona as well as private piano students in the community tested the tutorial, September – November 2005.
 - Tested by 1) fifty students in MUS 101A, 2) three graduate teaching assistants who teach MUS101A, 3) twenty-five students in MUS 361, 4) two piano pedagogy students, and 5) two private piano students.
 - Student completed surveys of each lesson: comments from students included at end of this document.
 - Graduate teaching assistants teaching MUS 101A relayed that they were able to challenge students to more profound levels of insight once a basic conceptual framework had been discovered by students' interaction with the tutorial.
- The tutorial will be implemented in the curriculum of MUS 101A, MUS 361, and MUS 107 (*Understanding Music Through Listening*) in the spring semester 2006.

4. Problems or Issues Encountered

- The programming and development of this software took an exorbitant amount of time well beyond what was initially anticipated to bring this project to completion.
- The modifications made to original interface following student feedback from November 2004 testing were extensive and carried the prototype to a more refined level in design and functionality; implementation of these changes required additional time.
- Editing and developing MIDI files of each composition for integration with interface was excessively time and labor intensive.
- A primary problem incurred was the necessity to contract a Macromedia *Flash* expert to develop the functional components of the interface. Even so, the person contracted was not available to devote full time to the project.

- Developing eight pieces from both a programming and pedagogical viewpoint proved well beyond the scope of the project; as a result only four pieces have been programmed.
- The functionality of the graphic interface and its interaction with the lessons has been in a continual state of evolution, thereby restricting and delaying the development of the associated tutorials of the remaining musical compositions.
- Pedagogical structure of lessons including both content and learner interactivity evolved into a more intricate, complex structure than originally anticipated. Development time required to integrate lessons within functionality of the graphic interface far exceeded what was originally predicted. This involved:
 - Creating, editing, and troubleshooting lesson content, interactivity and functionality.
 - Production of more than 100 embedded audio files as well as numerous image files that clarify the aural and visual patterns and shapes in the graph.
 - Features in lessons including multiple links to a glossary of terms, functional links that allow the learner to mute or hide selected layers of the composition, and pop-up boxes with audio and image files were deemed necessary after the project was underway.

5. Conclusions, Recommendations and Future Directions

Conclusions

While successful in achieving the baseline goal of developing an interactive learner-centered tutorial, this project required greater resources of time, expertise, and architectural direction than were available within the confines of the grant.

Recommendations

When programming of software is involved, it is recommended that a dedicated programmer or programming team be contracted so that consistent progress is made on the software.

Future Directions

- Attendance at workshops of the Office of Technology Transfer at the University of Arizona to investigate publishing possibilities including a general education piano textbook to accompany the *Interactive Piano Tutor*.
- Continued testing with students in the university setting, private piano instruction and review by pedagogical experts in piano, general music education, and multimedia design.
- Addition of more compositions for which a template has already been developed.
- Exploration of alternative coding language in lieu of *Flash* with the intent to secure a more suitable program to create the types of functionality needed for this interactive software.
- Tutorial can be implemented in diverse learning environments. The lessons can be used as written or, because the *Interactive Piano Tutor* can function as a standalone swf file, it can be embedded in any web page or course management system. This would allow instructors the flexibility to develop an individualized lesson addressing specific concepts or tailoring it to

an individual student or class. Hence, if the content is separated from the simulation, the simulations can be used in a variety of settings and customized as a learning tool for any student population.

- Principal Investigator is currently investigating new lines of research in learning objects and dual code processing and is developing an article with a colleague in the Treistman Center.

6. Has this project led to sustainable change in your department/college? Describe

Yes. This tutorial has been integrated into the curriculum of MUS 101A (*Exploring Music through the Piano for the General Student*). Additionally, the tutorial was tested in MUS 361 (*Music Learning and Perception in the Preadolescent*) and will be used in that curriculum in spring 2006. The tutorial will also be implemented in MUS 107 (*Understanding Music Through Listening*) in spring 2006. It has also been tested by graduate teaching assistants and piano pedagogy students at the University of Arizona and it will be an ongoing component of the piano pedagogy curriculum, used to introduce students to alternative systems of notation.

7. Impact

a. Have other faculty been affected by this project? Yes.

- Faculty teaching general musical education (MUS 107) will implement the tutorial in this curriculum, spring 2006.
- Faculty teaching applied piano were made aware of the tutorial.
- Received valuable input from music education faculty in development of tutorial.
- Faculty used the tutorial in MUS 361 (*Music Learning and Perception in the Preadolescent*) in fall 2005 to stimulate students' thinking as to the pedagogical value of using an alternative notational system to teach young children music. (See students' responses at end of this document.)

b. Number of courses affected/involved: 3

c. Number of students affected: 200

8. Significant Outcome

What was the most significant outcome based on learner-centered principles that occurred through your project?

By using an alternative representation of a musical score, the learners were able to use both visual and aural modes to integrate the graphic and audio information each lesson presented. Learners experienced more profound discovery in their interaction with the musical composition by viewing and listening to single or multiple layers of the composition, as well as by using application features to zoom in or out of the graph and to play the music from any location. The synchronization between the graphic representation and the traditional music notation provided a concrete interactive means for learners to discover relationships within the music. The self-tutorial also allowed each learner to discover the music at his or her own pace. When asked

which part of the tutorial provided the most enjoyable experience for the learners, their responses included the following:

“I really enjoyed the fact that along with the concepts there was a hands-on or practical application to it. And to be able to control the distinct layers and to see the graph is very useful.”

“I enjoyed being able to zoom in and out on certain parts and being able to turn the layers on/off because it allows me to delve more deeply into a piece of music and really pick it apart.”

“I liked being able to listen to all, some, or one of the layers and looking at the graph while answering questions. This made it interactive, which can help some who learn this way better.”

“I really liked the fact that you could click on the terms and a pop-up would come up with the definition of the term. It made the question more clear and precise. It was extremely interactive and thus captured my full attention.”

“I like the listening links. I want to train my ear to hear the difference besides seeing the difference.”

“I enjoyed the way the music was laid out graphically. It made it easy to follow and distinguish between the layers.”

“Watching both the graph and score simultaneously. It helps me better understand how to read music.”

“The best part about the tutorial is the various visualizations incorporated into the program. The ability to view the music in a variety of ways helps to truly understand the concepts.”

“Comparing between the graph and the score, seeing how the notes are in relation to one another.”

“I really enjoyed the ability to turn off and add the layers. This really helped to look at the piece in depth.”

“To visually see the music. I like this because I am a visual learner.”

“I liked being able to hear different parts of the music alone and together because normally, I could never do that.”

“I enjoyed the graph because it allowed me to see the layers that I might not have been able to hear.”

“The best part about the tutorial is its capability to perform multiple tasks at the same time. I like how you can listen to the song and watch its progress at the same time. Also, I like how you can zoom in on certain measures and take out layers.”

“I enjoyed the interactive graph and being able to configure the layers to hear certain ones together and alone because it allows my ears to distinguish the sounds when I later hear the piece with all the layers combined.”

Students in MUS 361 interacted with the conceptual framework of the tutorial and also used the tutorial to consider the pedagogical value of using an alternative notational system to teach young children music. Student responses from these interactions include:

“One advantage of using the graphic notation system is that student may more easily remember and internalize something that they can see as a visual /graphical representation. At young ages, pictures or any graphics become our way to key into significant concepts.”

“Many young students are newly being introduced to music and may not understand a music staff. Using a graphical representation allows for another visual of the music students are hearing. Since students have many learning types and abilities, the more ways to present information the better (Especially good for math students). A graphical representation also allows students to see the various layers they are hearing rather than just looking at notes. At such a young age, kids may not know what a teacher means by saying high ”C” etc., but the student knows/hears that high pitch. Using a graph lets students see the range with a continuous line, showing the variation of pitches within the song. It is also easy for students to create a graph of their own, representing what they hear when listening to a song. Also, the graph can easily show repetition, a musical concept students may not be able to pick up right away by listening to music or looking at a staff. Repetition on a graph can be demonstrated by the same line designs, color, etc. than can be shown to students while they are listening to a piece. The graph of the repetition will be easier to follow along with.”

“The advantage to using a notation system other than music staff are essentially ways to make a less complicated form for children to begin to comprehend music. In essence “training wheels” to music notation. By giving them an understanding of simply that a note rises and descends on the sheet, it helps them begin to visualize the patterns they will see in music staff. It also helps develop their basic reasoning that music is read left to right without the complication of the staff, clefs, and key signature. And finally, it can give them a basic comprehension of long and short, without having to understand the complication of notes and dots and flags. Thus, using a simplified notation system, while technically incorrect, is a good stepping stone for children to learn the first parts of the “language” of music notation.”