
Designing Undergraduate Instruction in Music Informatics

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Abstract

With the continuing advancement of technology, we see many new technological tools being developed that help us create and experience music, this development being referred to by many as “Music Informatics.” It is critical for our institutions of higher learning to foster the understanding of this development process so that musicians can harness this advancing technology for real musical benefit. Unfortunately, instruction in Music Informatics is limited to a sprinkling of graduate courses around the nation.

To that end, I have designed a 15-week undergraduate survey course that focuses on four main topics relevant to Music Informatics. This no-programming course is marketable to virtually any academic institution of higher learning with a music program, and can be taught by any professor with a minimum of background in music and technology.

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Section 1: Project Summary

For this research project, I have:

- Designed a 15-week, upper-level undergraduate course covering topics that many consider to be "Music Informatics" (MI) topics.
- Used several different forms of analysis and research methods to determine exactly how best to design this course.
- Created course materials for instructors and students to use in the course.
- Constructed and taught sample lessons to demonstrate the course environment.

Section 2: What is Music Informatics?

Going into this project, I had a very general definition of Music Informatics:

"Music Informatics describes the use of Information Technology to address issues raised by music performers, composers, theorists, researchers, listeners and anyone else who interacts with music in some way."

Through the course of this project, I have developed a more specific definition of Music Informatics:

Music Informatics is figuring out how to use new technological developments to make music more readily understood and accessible. Some topics that, in my opinion, fall under the "umbrella" of MI include:

1. *Music representation and visualization*
2. *Music Information Retrieval--using a database to store metadata and/or actual music content, and the efficient and relevant retrieval of this information*
3. *Digital Copyright laws and how they affect music creation/consumption today*
4. *Creating technology to aid in music performance-digital instruments, automatic accompaniment systems, etc.*

Section 3: Predispositions

Going into this project, I believed that:

- Music Informatics skills will have increasing relevancy and importance as time moves forward.
- Many schools teach a few subjects that fall under the umbrella of Music Informatics.

- Few schools teach many subjects that fall under that umbrella, and fewer still call it “Music Informatics.”
- Music Informatics skills are attainable for someone entering the business world after completing their undergraduate education in music.
- Many music professors (and some other non-music professors) would be able to teach a Music Informatics course.

Section 4: Needs Analysis

4.1 Summary of Needs Analysis

To determine the specific need for the instruction, I:

- Conducted exploratory research,
- Surveyed my target learner audience,
- Surveyed potential course instructors and
- Consulted with Subject Matter Experts.

4.2 Exploratory Research

4.2.1 Exploratory Research Summary

I decided my exploratory research would consist of:

- Investigating Informatics and Music Technology programs, as well as other related programs (music theory, music business, etc) at various universities (limited to Big Ten institutions for practical reasons),
- Comparing these programs and courses offered at these institutions,
- Determining if certain MI topics were or weren't being taught in these courses,
- Determining if universities had the resources to teach an MI course, if none existed and
- Determining the specific need for MI instruction.

4.2.2 Results from Exploratory Research

- Indiana University has the only Music Informatics graduate program in the Big Ten. No universities offer an undergraduate Music Informatics major.
- No universities currently offer a Music Informatics course for Undergraduates (Indiana used to, team taught by Donald Byrd, Chris Raphael and Ian Knopke).
- Many universities (five of the eleven Big Ten universities) offer graduate or undergraduate courses in what they call "Music Technology."
- All of the Big Ten universities (except for Michigan St.) have “Informatics” programs, with the most common specialties being Bio or Medical Informatics.
- Three Big Ten universities (UIUC, UM, Purdue) offer undergraduate majors in “Informatics.”
- Schools with particularly good resources for studies involving music technology include Indiana, IUPUI, Minnesota, Penn State and Northwestern.

4.2.3 Insights from Exploratory Research

- Many universities could, in theory, offer a Music Informatics course.
- I still need to determine if there is a specific need at these schools for this course.
- I still need to determine the exact specifications of the course.
- I need to learn more about my two target audiences: the students and the instructors.

4.3 Surveys

4.3.1 Summary of Surveys

To learn more about my two target audiences, I designed two surveys:

- Probable learners (upperclass Music Theory/Music Technology/Music Business students)
- Probable instructors (tenured Music faculty)

The surveys were hosted on SurveyMonkey.com from January 22-March 22. Each was 17 questions in length, and took an average of 4 minutes to complete.

4.3.2 Student Surveys

Unfortunately, I did not receive enough responses from students to generate any statistically significant results.

4.3.3 Instructor Surveys

- 110 Instructors from Big Ten universities were surveyed
- Surveys sent via e-mail
- 31 responses (27.2% response rate)
- Detailed responses: http://www.martinmccrory.com/capstone/survey_summary.xls

4.3.4 Insights from Surveys

- I need to slightly re-think my specific definition of Music Informatics (to more accurately reflect the state of affairs with regard to digital instruments).
- Creating in-depth instructor materials may be a waste of time.
- **Instructors that do know programming are sometimes willing to incorporate programming into their courses.**
- **Instructors that do NOT know programming absolutely will NOT include programming in their courses, and are reluctant to learn even a simple programming language if it is required for the course that they teach.**
- Young music theory instructors generally know most of the subject material related to Music Informatics.
- Older music theory instructors may not be the best candidates to teach a Music Informatics course.
- Some (but not a lot) of music theory courses use technology to the extent that this course would.
- Instructors generally believe that there would be interest at their university for a Music Informatics course.

Section 5: Computer Programming

At this point in my research, I decided that students in this course should not be required to do much in the way of computer programming. This decision has prompted vigorous debate with my Music Informatics colleagues. Many are against the removal of computer programming for the following reasons:

- Music Informatics is a rigorous scientific course of study, and doing computer programming encourages a rigorous scientific approach to the subject.
- Much of what Music Informaticians do in the “real world” is computer programming, so a course that teaches this should reflect that.
- Doing computer programming allows for students to “learn by doing” and personally experience the tools they’ve been studying.

However, I decided that including computer programming in what is essentially a survey course of Music Informatics would bring up more problems than it would solve:

- Doing computer programming in a Music Informatics course would either (a) require a few weeks of time set aside to learn the programming language/environment (b) require a prerequisite of a computer science course that few members of my target audience would have taken.
- In the “real world,” developers learn new programming languages and environments frequently, and often these environments have specific development characteristics that are virtually impossible to teach in a generalized course.
- Sometimes, it is difficult to use programming to “learn by doing,” as often the main message of an assignment gets lost in a myriad of technical challenges that a student faces during the programming process.
- Including programming in the course curriculum limits the instructors who can teach the course.

Finally, leaving out programming from a Music Informatics course still allows for a deep level of thought and discourse on the subject:

- Students can still experience programming through the use of “plain English” algorithms, or the use of pseudocode. Often, this is a more direct way to “learn by doing,” as the technical issues with programming are completely bypassed in order to get right to the core issues of the assignment.

- There are other ways to demonstrate scientific rigor in the course besides computer programming, such as using the Scientific method to compare existing algorithms.
- Lastly, and perhaps most importantly, **Learning how to think at a high level about the theory of Music Informatics is more important than learning some programming environment “halfway.”** Students will eventually learn the technical tools they need to do their job in the “real world.” However, teaching students how to think critically and creatively about Music Informatics subjects is a universal skill that can be used in any job after the course is complete.

Therefore, students in this course will not be required to do any formal computer programming or learn any formal programming languages or environments. Students will, however, be required to use pseudocode at times to write algorithms, study existing code and point out flaws/characteristics and perhaps interact with programming environments on a limited level during select case study exercises.

Section 6: Context Analysis

6.1 Learners

From the survey information, I determined that my learners generally will consist of:

- Music students (music theory or music technology, with some performance/history/ed taking the course as an elective)
- Technology students with an interest in music taking the course as an elective

6.2 Instructors

Generally, the instructors for the course will be:

- Music theory/technology professors (though this is not completely certain, as I only surveyed Music theory/technology professors), or
- Possibly business/computer science professors with an interest in music.

Regardless of the department in which they are employed, the instructor likely knows some computer programming. However, it is not a requirement to teach the course.

6.3 Classroom

- Class size and classroom should be small.
- Student computer workstations must be available for internet/program access.

Section 7: The Course

7.1 Course Summary

- The course lasts 15 weeks, consisting of an overview, four technical units and a conclusion.
- Each technical unit tackles a specific topic that falls under the “umbrella” of Music Informatics.
- In each unit, learners either give a group oral presentation or write a short paper (see section 7.2.2).
- At the end of the overview and conclusion, a practical exam takes place (see section 7.2.1).

7.2 Course Deliverables

7.2.1 Essay Exams

There are two essay exams, one each at the beginning and end of semester. Both exams are problem-based, and ask students to address real-life Music Informatics issues.

Students are graded on the depth of their response, the validity and logicity of their solution. The first exam is graded "easier," like a homework exam—its purpose is to give the instructor a sense of the student's prerequisite knowledge, strengths and weaknesses, as well as to form groups for the oral presentation. The second exam is graded "harder," like a

true final exam. Students are expected to synthesize information from the relevant technical units, come up with unique and deep solutions to the problems given, and to argue their points with ferocity and logic.

7.2.2 Group Oral Presentation

The class is divided into four groups (one for each technical unit). Each group gives a presentation in one of the units. For example, Group A gives a presentation in Unit 2, Group B gives a presentation in Unit 3, etc. Groups and units are assigned by the instructor. The topic of the presentation is the students' choice related to the Unit in which the presentation was assigned. A grading rubric for the oral presentation can be downloaded at <http://www.martinmccrory.com/capstone/rubric.pdf>.

7.2.3 Unit Papers

In the three units in which a student's group is not giving an oral presentation (and excluding the overview and summary portions of the course), students will be asked to write 750-1250 word essays that offer a solution or prototype model to a real-world Music Informatics problem related to the Unit in which the paper was assigned.

7.2.4 Case Study Readings and Exercises

Students will do case study readings and/or exercises for almost every class period. Readings may come from online or printed sources. Exercises may be watching videos on YouTube, playing with Flash applications, viewing sheet music, or anything relevant to the unit. These case studies serve to illustrate relevant and interesting examples of the material discussed in class. There will be approximately 26 case studies.

7.3 Course Syllabus

The complete course syllabus can be downloaded at <http://www.martinmccrory.com/capstone/syllabus.pdf>.

Appendix A: Sample Lessons

A.1 Introduction to Music Genre Classification (Week 7)

A.1.1 Instructional Objectives

The objectives of this lesson are to:

- Allow students to explore how humans classify music
- Expose the student to the creation of algorithms for automatic genre classification

By the end of the lesson, students should be able to:

- Label specific, musically valid reasons why they personally classify music into genres
- Describe at least one method a computer may use to perform genre classifications

A.1.2 Lesson Overview

Students first perform manual genre classification, in the following manner:

- Each student is given a matrix, with each row representing a genre and each column representing a candidate song (for an example matrix, see Appendix 2).
- Each candidate song is played.
- Students mark which genre (only one genre per candidate song) the student feels best represents the candidate song.

After the marking period, the genre classifications for each song are tallied on the board. The instructor leads students in a discussion of the following concepts:

- Why did you classify the song into this genre?
- What specific features in the music led you to this decision?
- Why is there disagreement with this song (if there is disagreement among the students)?

Lastly, the instructor should lead students in the following discussions:

- How might a computer classify music into genres?
- Could a computer use the same lines of thinking that you did when classifying music into genres?

- How could a computer perform automatic genre classification? Would it be at all like how we just did it?
- Can you think of circumstances in which it would be useful for a computer to perform automatic genre classification?

A.2 Copyright Laws and their affect on music creation/consumption (Week 10-11)

A.2.1 Instructional Objectives

The objectives of this lesson are to:

- Inform students of what current and former copyright laws in the U.S. are (relating to music)
- Have students create and defend a stance on certain issues relating to Intellectual Property rights

By the end of the lesson, students should be able to:

- List what some of the current copyright laws are in the U.S.
- Describe the Digital Millenium Copyright act and at least two ways that the DMCA affects the creation and consumption of music
- Define “fair use”
- List at least three ways in which filesharing systems affect the creation and consumption of music

A.2.2 Lesson Overview

The lesson begins with a hands-on group exercise, to establish a baseline of copyright treatment over time:

- The classroom splits up into several groups.
- Each group takes 10 minutes and researches the state of copyright laws (in the U.S.) during a given time period.
- The time periods are: {beginning of time-1849, 1850-1960, 1960s, 1970s, 1980s, 1990s, 2000-2005, 2006-present}
- After the deliberation, the smaller groups report back to the larger group with their findings

Next, the instructor gives a short lecture on the current state of copyright laws in the U.S.:

- Summary of important copyright legislation in the past 3 centuries
- Sonny Bono act of 1998
- How these legislations affect how works available for consumption today are held in copyright

Group discussion on the following topics:

- Digital Millenium Copyright Act—what it is, how it affects music creation/consumption
- Fair Use—what it means and how fair use restrictions affect creativity (example: scrambled hackz)
- Digital Rights Management—what it is, some common examples, and how DRM affects music creation/consumption
- Filesharing/P2P networks—some examples of common filesharing systems, how they affect music creation/consumption

A.3 Introduction to Audio Music Visualization (Week 5)

A.3.1 Instructional Objectives

The objectives of this lesson are to:

- Introduce students to audio-based forms of music visualization
- Teach students how sound waves propagate through air
- Instruct students how to combine basic sine waves to create new sound waves

By the end of the lesson, students should be able to:

- Name the three basic forms of audio-based music visualization
- Describe how sound moves through air, and how a time/amplitude representation precisely describes this movement
- Combine sine waves (using an online tool) to create special sorts of waves (square/sawtooth wave, approximations of traditional acoustic instruments)

A.3.2 Lesson Overview

The lesson starts with a summary of the three “basic” forms of audio visualization:

1. Time-domain visualization (domain: time, range: amplitude)
2. Frequency domain visualization (domain: frequency, range: amplitude)
3. Piano roll visualization (domain: time, range: frequency)

The lesson today focuses on the time-domain visualization. Firstly, the instructor starts with a simple overview of how sound works:

- Sound forms when the air around us becomes displaced in a certain fashion.
- If the air is displaced with enough “force” (a high enough amplitude) and does so repeatedly enough for us to perceive it, we hear a sound via our ears.
- Some examples of things that can create this displacement: a stereo speaker vibrating back and forth, a string on an instrument vibrating up and down, our vocal chords displacing air via a similar vibration, etc

Next, the instructor correlates how sound is formed to the visualization:

- In a simple sound wave [no harmonics], the air vibrates up and down at a constant rate until the source of the vibration stops vibrating the air. (example: speaker playing A440 at a constant rate).
- If you were to “tag” a specific molecule of air with a locator beacon, and mark its position relative to the ground, you’d notice that, during the vibration, it “bounces” up and down at a periodic rate—the number of Hz (cycles per second) at which the sound was created!
- The time-domain visualization captures this “bounce”—the domain illustrates how long it takes the “bounce” cycle to complete (period) and the range illustrates how high it bounces (amplitude).

Next, the instructor describes how these simple waves are “combined” to form more complicated waves:

- Unlike the visual world, where two objects can’t be in the same place at the same time, sound waves *can* combine to form new and more interesting sounds!
- Our ear can hear multiple sound waves at the same time, and our brain combines them into one sound. We can harness this ability of our brain to create more complicated sounds.
- Imagine that, instead of one speaker oscillating the air at a constant rate, you have a large number of speakers, each one tuned to a different frequency, each one oscillating the air at a constant (but different) rate. This allows for many new sounds to be created.
- Certain frequencies (related to the lowest frequency being heard, usually called the “fundamental”) are special. Particularly, frequencies that follow what’s known as the “overtone series” (basically even multiples of the original frequency) can be used to create unique “timbres” (a musician’s word that describes the difference in tone quality between two sounds of identical frequency).

Lastly, to illustrate these last few points, the instructor directs students to an online tutorial that allows students to create sound waves by choosing harmonics, their amplitudes, and their “phase” (when they turn on and off). The URL to this tutorial can be found at: <http://www.falstad.com/fourier/>.

Appendix B: Sample Essay Questions

1. Your elderly aunt Irma is considering buying a computer for the first time. Irma is a music aficionado, lives on the Upper West Side of NYC, and has been attending musical performances at Lincoln Center for years. She has an extensive record collection and a 20-year-old record player with which to enjoy her music. She claims she’s buying the computer “for the internet” and “to check on my grandkids,” but you know better. You know that her musical experiences are all about to change, as well. Explain to Irma, in simple but conceptually accurate terms, how the way she experiences music will change if she purchases her laptop. Write your answer in dialog form.
2. You are a sales consultant hired by a local record store (NOT a big chain like Borders). Their sales have fallen 30% over the past 18 months, and your job is to find out why. Of course, you know why—mp3 downloads, legal and illegal—are to blame. However, there are likely some other factors at play here. Give a full report to the store manager, detailing

exactly why his record store is failing and what she can do to get her store back on track. If you need specific details about the store, make them up.

3. You want to start a music social networking site. You want its functionality to include things such as the ability to listen to, share, rate, tag, sort, store and discuss music, create, share, rate and store playlists, and give artists a chance to showcase their musical talents. Technically speaking, how do you think you could accomplish this? If you are not familiar with the specific technological tools that you'd use to perform a task (say, implement a metadata-based social music tagging system), explain in loose terms what your tools would accomplish, and how, in theory, they'd accomplish them. Use pseudocode in instances where you are describing how an algorithm may work.
4. You are a distinguished professor, specializing in information science at a Big Ten university. Music has always held an interest for you, and you believe that today's technology has a lot to offer in terms of improving the way we can understand and manipulate music and sound. You want to encourage other technologically-minded academics to develop new tools to accomplish these goals. How would you go about doing this? Explain in detail what steps you'd take, what systems you'd use, and what your end result would look like.
5. You are a lawyer defending a high-profile music producer, who is charged with multiple counts of copyright violation. In private counsel with you (meaning, he has NOT testified to this yet), he has informed you that he did sample other musician's works, but most of them were only small, barely recognizable snippets of the original. This is a high profile case, with the potential to shape the way future music copyright law cases are litigated. Explain your defense strategy. How can you convince a jury that your client should not be indicted under current United States copyright law? Is he completely innocent? Or is he probably guilty, but perhaps the jury should take pity on your client? Include responses to predictable counterarguments, and appeal to what you feel is morally right.
6. You are a senior software engineer at a large company that specializes in multimedia software production. You are working on a large-scale consumer-oriented audio editing and manipulation suite (such as Cubase). Propose a design for a new type of music visualization that you believe would add functionality to this suite. Justify why this design is worth incorporating, and outline, in broad strokes, the technical characteristics of this visualization. Try to propose a design that doesn't already exist 😊
7. You work for the Nowhereville Symphony Orchestra, a nonprofit orchestra with an aging clientele. You have a good computer programming background. You propose to your boss an idea that you believe will attract a younger audience to NSO concerts—free, live streaming of concerts, as well as archived access to low-fidelity audio recordings of NSO performances! Your boss says that it's a great idea and wants to know more. Explain to him why you feel that this is a good idea, why it will work, and how you'd go about implementing it.
8. Continuing with the above question, you are the boss's wife, who is a professor of Music History at Nowhereville University. You overhear the previous interchange, and you're not as thrilled as your husband (the boss) about the idea. What's wrong with this idea? Could it be implemented with a few changes, or is it fundamentally flawed? Why?