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Research Paper 1: Computer Music Today

Computer science and music production share a common problem: it's difficult for the average person with no background experience to get involved in these fields. Consequently, they lack participation from groups that would benefit from and ultimately contribute to these subjects. Programming has historically been a study dominated by older white and Asian men; young people outside of this description are hesitant to or lack the resources to get involved. Young people are constantly listening to music but rarely get involved in creating it: a study showed 83% of students listen to music for at least one hour every day, but "only 6% have mixed or composed their own music before".[1] EarSketch, a computer music program, addresses both problems at the same time. EarSketch is an integrated computer and music composition learning environment that requires no prior knowledge of either field and, by engaging teens of all backgrounds through its alignment to pop culture, is able to spark their pursuit of studies and careers in CS or music and ultimately improve these fields as well as the lives of minority groups.

EarSketch works so well because programming and music composition, two subjects the average person thinks have nothing in common, are built on the same foundations of concept and functionality. Code and music inherently involve a multitude of the same concepts. Just as programming involves different types and lengths of loops of code, music involves layers of repetition and loops-- especially the kind of popular music teenagers are interested in, which is essentially all patterns of repeated embedded loops of beats. Brian Magerko, professor of digital media at Georgia Tech, notes that many of the fundamentals taught in intro CS courses apply very closely to aspects of the music production process.[2] For instance, one may employ the concept of randomness, letting the computer to choose the timing or note of a beat and creating

[1] Jason Freeman et al., "Using EarSketch to Broaden Participation in Computing and Music."
[2] TEDx Talks, *The Magic of Music in Computer Science Learning | Brian Magerko | TEDxPeachtree*.

spontaneity in the music that replicates a human performance.[3] Or, for example, musicians can take advantage of the concept of user defined functions to define a chunk of music as the chorus, or define a snippet of beats and sounds repeated in various parts of the song, making it easy to identify and switch around sections of the song.[4] Another example of the overlap in functionality between computing and music and how it improves the EarSketch user experience, is how EarSketch "represents beats as Strings", a series of characters, so students can easily manipulate beats using standard Python methods like reverseString(), shuffleString(), and replaceString().[5] Thus, beginning programmers are learning String operations "in tandem with serial, stochastic and other approaches to the manipulation of musical events".[6] Indeed, creator of EarSketch Dr. Jason Freeman notes the seamlessness of simultaneous education in programming and music, saying "as the kids are learning about what makes a good song--how to orchestrate different layers, how to work with loops, how to organize things like pitch and rhythmic content-- at the exact same time they are learning how to write functions or loops, and how to fix code when it has bugs".[7] The table shows more examples of the shared characteristics between coding and music composition.[8] Ultimately, "the key principle behind the curriculum design has always been to provide authentic, compelling reasons for the combination of music and programming rather than relying on a trivial or superficial overlap of one on the other that could quickly lose student interest or engagement." And indeed, EarSketch's "intertwining of STEM and artistic content" truly does take advantage of the shared themes between music and computing, leading to its ease of use and therefore its success.[9]

Computing Concept	Musical Concept
Variables	Easily change musical samples in a piece
User-defined functions	Musical sections
Audio effects	Math operations
Iteration	Automation of operations
Arrays/lists	Containers for samples and beats
Matrices	Sonification of data
Recursion	Self-similar musical tracks
Intellectual property	Music and software copyright

[3] TEDx Talks.
[4] TEDx Talks.
[5] McCoid et al., "EarSketch."
[6] McCoid et al.
[7] "EarSketch."
[8] Magerko et al., "EarSketch."
[9] Magerko et al.

EarSketch is designed for high school aged youth with no prior knowledge of music theory nor computing. EarSketch integrates a Python programming environment with a commercial digital audio workstation (DAW) program that allows students to create music through the combination of writing code and using some basic music production strategies.[10] EarSketch makes it easy for students to compose real music "without the added barrier of entry of learning music theory about harmony, melody, chord progressions, and so forth" by "focusing on composing with musical samples, beats, and effects", and by providing a software toolset that lets users manipulate loops, compose beats, and apply effects with Python code.[11] The toolset organizes the almost 2,000 short audio loops into packs designed to be seamlessly combined and layered together, and the loops automatically time stretch to match the tempo chosen by the student with the setTempo() function. A sound browser helps one quickly preview and compare loops, and functions needed for common manipulations of beats--reverseString(), shuffleString(), and replaceString()--are provided.[12] [13] These aspects of the functionality make it simple for anyone to get started making music. And, simultaneously, teens will internalize the core concepts, implementation, and syntax of "industry-relevant, text-based programming languages", Python and, in the newest version of EarSketch, JavaScript. [14]

Furthermore, not only can students with no prior experience immediately start creating music, but EarSketch lets them create high quality tracks that reflect their favorite kind of popular music. For one, the DAW EarSketch employs, Reaper, is comparable to those used in professional recording studios.[15][16] Secondly, the thousands of audio loops are in modern popular styles "ranging from hip hop, dubstep, and house to techno and electronica" that "provide a

[10] McCoid et al., "EarSketch."
[11] Magerko et al., "EarSketch."
[12] McCoid et al., "EarSketch."
[13] Magerko et al., "EarSketch."
[14] Magerko et al.
[15] Magerko et al.
[16] "REAPER | Audio Production Without Limits."

powerful, culturally situated motivational context".[17] Furthermore, the audio loops were created by Richard Devine, "an electronic musician who has designed audio for clients such as Coca-Cola and Apple", and by Young Guru, "Grammy-nominated audio engineer known for his long-running collaboration with Jay-Z"[18] Thus, the combination of the high quality and contemporary style of the sounds built into the platform, with the way the toolset makes it possible "to achieve the multilayered textures" common to the style of popular music today, yields recording-studio level music.[19] These characteristics make EarSketch truly engaging and useful to teens.

Students play their tracks by running their Python script, "seeing audio waveforms appear in rapid animation in the DAW window as the code executes".[20] Users can overlay their own vocal or instrument recordings over programmed music, upload their music and source code to the social media site, and "create derivative musical remixes from other students' code" from the site.[21] If students want to master the coding techniques necessary to make great music in EarSketch there is a free curriculum text on the website that covers introductory computing concepts "in the context of computational music remixing."[22] EarSketch and its online curriculum text also may be useful for teachers as supplementary work or a project for students, and it integrates well into high school CS classes, as the program and curriculum text "are closely aligned" with the content of the Computer Science: Principles AP class and Georgia's High School intro computer science classes.[23]

Virtually all teenagers, and people in general, have one thing in common: everyone likes music. A love for music spans all genders, ages, races, and ethnicities. On the other hand, the field of computer science is not the most diversified, being historically dominated by older white or Asian men. There is, perhaps, among teens who do not fit this description, a certain

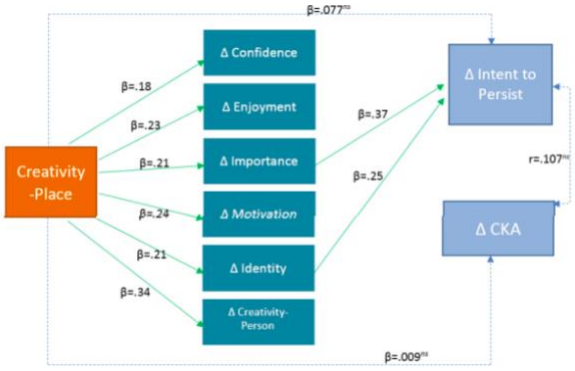
[17] Magerko et al., "EarSketch."
[18] Magerko et al.
[19] Magerko et al.
[20] Magerko et al.
[21] Magerko et al.
[22] Magerko et al.
[23] Magerko et al.

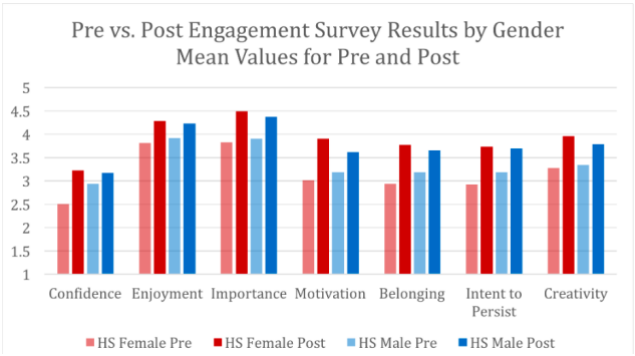
intimidation or hesitation around getting involved in computer science courses because the subject seems foreign and reserved for a certain group. Thus, introductory CS courses "are not currently successful at reaching a wide range of students, especially under-represented populations such as women and ethnic minorities".[24] But, the beauty of EarSketch's integration of music and programming has the power to change this. EarSketch attracts users of all backgrounds due to this universal enjoyment of music, and in these users' simultaneous education in coding, it grows and diversifies the pool of computer programmers in the world. EarSketch "really catches particularly youth culture but also culture in general, a popular culture."[25] This connection to the average teen, no matter their gender or color, exposes underrepresented groups to computing, something they likely could have never gotten involved in otherwise. For example, Georgia Tech student Daisha White explains, "I do appreciate [that] I got to learn [EarSketch] in 9th grade because now I'm going to college for it…it's important that at a younger age you get a little bit of [computer science] to know if you like it or not."[26] EarSketch attracts teens of all backgrounds due to the common interest of mixing music, and ends up often sparking a passion for computer science. Mike Reilly, computer science teacher at Lanier High School in Georgia says "it is [his] favorite method to introduce computer science," because it "conveys core CS skills while capturing the attention of the entire spectrum of students." In other words, it "connects to students in a culturally relevant fashion that spans gender, ethnicity, and socioeconomic status", ultimately "increasing engagement in computer science, particularly among groups traditionally underrepresented in the discipline". [27]

Furthermore, not only does EarSketch genuinely interest and engage a wide variety of students, but it builds their confidence and positive attitude towards programming, hugely increasing the likelihood that they'll pursue future classes or careers in CS. And, with such a

[24] McCoid et al., "EarSketch."
[25] "EarSketch."
[26] "EarSketch."
[27] Magerko et al., "EarSketch."

high demand for programmers in the job industry, EarSketch can send teens down a path toward a better future and, for minorities who wouldn't have had access to a computing education without EarSketch, perhaps a better socio-economic status. The platform's creators' research discovered that students' motivation to pursue subsequent CS classes and/or a career in computing "is partly contingent on gains in the following: Perceptions that computing is important and useful for their futures (Importance), and feelings of belongingness in the computing domain (Identity)," as shown in the figure on the left.[28] In other words, the key to retaining student participation is, first, their understanding that programming is an extremely beneficial skill, and second that even though they may be a minority in the field, they are capable and belong. And indeed, after using EarSketch teens "show more confidence or self-efficacy in computing, enjoy computing, perceive computing as more useful in their own lives and in the real world, express more motivation to succeed, feel a sense of identity and belonging, and are able to engage in expressive, creative thinking skills".[29] Using underrepresented genders as an example, the figure on the right shows that in a 27% female and 73% male class (a typical gender breakdown for CS courses), "across all constructs, female students are less engaged than their male counterparts before they study EarSketch but are more engaged than the male students after studying EarSketch."[30] These Females showed "significant" changes in "confidence, motivation, identity and belongingness". [31]





[28] Engelman et al., "Creativity in Authentic STEAM Education with EarSketch."
[29] Engelman et al.
[30] Jason Freeman et al., "Using EarSketch to Broaden Participation in Computing and Music."
[31] Jason Freeman et al.

Such mental shifts lead to students' continuation in a CS education and perhaps the pursuit of a career in computing. Additionally, as Dr. Freeman explains, "coding is at the same level of importance as reading and writing now. It's a way of thinking logically and computationally, and is becoming essential not only for jobs in tech industry but for jobs in almost every sector of our economy".[32] So, EarSketch's "authentic and creative learning experience", which builds students' confidence and sense of identity as a programmer, increasing "students' attitudes and intent to persist" studying programming in college, may increase their chances of getting a job, and perhaps a better one than they would've having not pursued CS.[33] This is the ultimate social impact of EarSketch: to engage women and minorities in CS, to get them passionate about programming, and to jump start them on a path of CS study and work that can ultimately improve their lives. Plus, the added participation of women and minorities to careers in subjects of both computer science and music will broaden and progress the fields. All in all, EarSketch takes teens who wouldn't have thought to study CS or didn't have the resources, gives them an engaging, full curriculum, and sends them down a path that could seriously alter the trajectory of their life for the better.

EarSketch is altering the horizon of the fields of both music production and computing. For so long these industries have lacked participation from large portions of the population. Before EarSketch, computing was reserved for white and Asian males, and no one without certain resources and a knowledge of music theory thought to produce his or her own music. EarSketch makes a computer science education accessible, makes creating culturally-relevant, high quality music easy, and simultaneously exposes teens to new areas of interest that they may want to pursue in college and careers. This yields a mutually beneficial result for both the students themselves and for the fields of music and CS. It has the ability to give passionate, driven underrepresented groups better lives in the future, and to grow and advance music and

[32] "EarSketch."
[33] Engelman et al., "Creativity in Authentic STEAM Education with EarSketch."

programming industries by broadening and diversifying participation in the fields. EarSketch is much bigger than itself, and "it has even more potential than the founders realize".[34]

[34] "EarSketch."

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