EarSketch: a STEAM approach to broadening participation in Computer Science Principles

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***Abstract*— The EarSketch computer science learning environment and curriculum (http://earsketch.gatech.edu) seeks to increase and broaden participation in computing using a STEAM (STEM + Arts) approach. EarSketch creates an authentic learning environment in that it is both personally meaningful and industry relevant in terms of its STEM component (computing) and its artistic domain (music remixing). Students learn to code in JavaScript or Python, tackling learning objectives in the Computer Science Principles curricular framework as they simultaneously learn core concepts in music technology. They create music through code by uploading their own audio content or remixing loops in popular genres created by music industry veterans. No prior experience in music or computer science is required. EarSketch is entirely browser-based and free.**

Keywords*— *computer science principles; music; remixing; Python; JavaScript; broadening participation; agent-based modeling; creativity

I. INTRODUCTION

In disciplines ranging from science to the humanities to the arts, computational thinking has become central to how we create, communicate, experiment, evaluate, iterate, and innovate [1], [2]. However, we have yet to make major strides in developing computing literacy as a core 21st century STEM skill for tackling multidisciplinary problems [3]. Computing education in the United States currently struggles to engage students and motivate their further studies in the discipline [4]. A recent NSF report noted the steady decline of women enrolled in computer science over the past decade, even as more women have pursued other STEM fields [5]. African American and Latino students are vastly underrepresented in computing courses such as the current Advanced Placement CS course, compared to their Caucasian and Asian counterparts [3].

EarSketch seeks to increase and broaden participation in computing by creating an engaging and culturally relevant learning experience using a STEAM (STEM + Arts) [6] approach. EarSketch creates an authentic learning environment [7], [8] in that it is both personally meaningful and industry relevant in terms of its STEM component (computing) and its artistic domain (music remixing).

Our current EarSketch research hypothesizes that by 1) incorporating EarSketch into a high school Computer Science Principles (CSP) [9] course, 2) actively recruiting Georgia schools with large populations of minority students, and 3) providing online professional learning for teachers, we will a) increase and broaden successful participation in high school computer science in Georgia, and b) demonstrate positive engagement and creativity by students, particularly among populations traditionally under-represented in computer science.

Our main research questions are:

- To what extent does an EarSketch-based CSP course promote student achievement and engagement across different student populations?
- To what extent does EarSketch promote student performance, creativity, collaboration, and communication through techniques adopted from studio-based learning, problem-based learning, and communities of practice?
- What factors enhance or impede effective implementation of EarSketch in different school settings?

Our research is studying the extent to which EarSketch promotes student achievement, engagement, creativity, collaboration, and communication across different student populations in CSP courses in Georgia high schools. We are combining existing instruments for measuring student engagement in computing with new instruments for measuring CSP content knowledge and student creativity. We are also employing an agent-based modeling [10] approach that leverages techniques from industrial and systems engineering, in conjunction with social network analysis, to model the relationships, agents, and attributes that comprise the educational settings in which EarSketch is deployed.

II. EARSKETCH

EarSketch is a web-based product that integrates a programming environment, digital audio workstation, curriculum, audio loop library, and social sharing features. Targeted primarily to the high school level, the EarSketch software is in constant development. The key features of EarSketch include allowing students to: create music in many different popular music styles (ranging from hip hop and dub step to techno and pop) and share them; write code in Python or JavaScript; remix thousands of sounds from Young Guru (Jay Z's audio engineer) and Richard Devine or upload

students' own sounds; and learn to code and make music with no prior experience in music or computer science.

III. Curriculum

With EarSketch it is possible to learn core topics in computer science, music, and music technology together in an engaging, student-centered environment. EarSketch provides a modular curriculum designed for use within a high school or college introductory computing course. It is aligned particularly closely with Computer Science Principles. Teacher materials include day-by-day lesson plans for an 8-week CSP course module that covers the learning objectives, essential knowledge, and computational thinking practices associated with big idea 5 (programming). All curricular materials are released under a Creative Commons license.

IV. Deployment and Professional Learning

We have built a strong partnership with district leadership, school leadership, and individual CS teachers throughout Gwinnett County Public Schools, the largest district in Georgia. During the 2015-2016 school year, four CS Principles teachers in the district will use EarSketch in their CSP courses and participate in our research studies. We have also built relationships with other districts as we grow the number of schools in future years of research. We have specifically targeted collaborations with schools with high proportions of students from groups traditionally underrepresented in computing.

To facilitate deployment, we conducted a 3-day professional learning workshop for teachers from three different Georgia school districts in summer 2015. We are currently developing an online version of our professional learning workshop so that we can scale training to larger numbers of teachers in future years.

V. Agent-Based Modeling

To create a model for studying a STEAM intervention we are leveraging a framework being developed as part of a related Georgia Tech research project, *Advanced Manufacturing and Prototyping Integrated to Unlock Potential* (AMP-IT-UP). The modeling framework is a process for creating a model, simulating the model, and analyzing the model for a unique school setting and educational intervention. The overall approach is to use Agent-Based Modeling [10] in conjunction with social network analysis to model the relationships, agents, and attributes that comprise an educational setting.

The EarSketch implementation across diverse settings provides a suite of test cases that can be used to create and validate a model for STEAM interventions. After the model is created, it can be used to identify what commonly enhances or impedes effective EarSketch implementation. In addition to determining the most important factors that enhance or impede successful implementation, we also aim to develop models that can predict a priori whether a similar intervention is likely to be successful in a new school setting.

VI. Research Instruments

In order to address our main research questions, the project is using a combination of existing research instruments, instruments adapted and extended from other contexts, and entirely new instruments developed by the team. Current work in instrument development includes:

- Creating student and teacher intake questionnaires that align with the attributes required for our agent-based model.
- Developing a set of questions to include in our student engagement survey to measure creativity.
- Developing a content knowledge assessment that is language agnostic (and so suitable for use in comparison studies) and aligned with the programming big idea in Computer Science Principles.
- Developing a rubric for evaluating student projects in terms of Computer Science Principles learning objectives and in terms of creativity in both the technical and musical domains.

VII. Conclusion

The EarSketch research project contributes to changing how computing is taught, serving as a core curricular component of computing courses. Our research builds on engaging underrepresented groups in STEM and will help bridge the gap for women and minorities in computing. The culmination of this work will be a robust, fully usable online learning environment, along with a systems-level understanding of best practices and challenges for implementing it – and other STEAM approaches like it – within high school courses.

References

[1] J. M. Wing, "Computational thinking," Commun. ACM, vol. 49, no. 3, pp. 33–35, 2006.

[2] J. M. Wing, "Computational thinking and thinking about computing," Philos. Trans. R. Soc. Math. Phys. Eng. Sci., vol. 366, no. 1881, pp. 3717–3725, 2008.

[3] J. Cuny, "Address to the Computer Science Community," 2011. [Online]. Available: http://ww2.ncwit.org/pdf/Jan_opening.pdf.

[4] Cuny, J. Address to the Computer Science Community. 2011.

[5] L. Sanders, "NCWIT Orientation," 2012. [Online]. Available: http://ww2.ncwit.org/pdf/Summit2012_NCWITOrientation.pdf.

[6] J. Maeda, "STEM + Art = STEAM," STEAM J., vol. 1, no. 1, 2013.

[7] H.-S. Lee and N. Butler, "Making authentic science accessible to students - International Journal of Science Education," Int. J. Sci. Educ., vol. 25, no. 8, pp. 923–948, 2003.

[8] D. W. Shaffer and M. Resnick, "Thick authenticity: new media and authentic learning," J Interact Learn Res, vol. 10, no. 2, pp. 195–215, Dec. 1999.

[9] The College Board, "AP Computer Science Principles: Draft Curriculum Framework," Aug-2013. [Online]. Available: http://media.collegeboard.com/digitalServices/pdf/ap/2013-0607-comp-sci-principles-cf-final.pdf.

[10] N. Gilbert, Agent-based models. Sage, 2008.