A Qualitative Study on Engaging Students in Computing Through Computational Remixing with EarSketch

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A QUALITATIVE STUDY ON ENGAGING STUDENTS IN COMPUTING THROUGH COMPUTATIONAL REMIXING WITH EARSKETCH

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SUMMARY

Despite it being a rapidly growing field in today's society, computing fails to engage substantial numbers of underrepresented minority populations such as women and African Americans. In today's world, the number of tech jobs is increasing far beyond the number of students enrolled in computing programs. There have been many attempts to engage underrepresented populations in computing through outlets such as gaming, but these attempts have not been as successful as hoped. My research focuses on a new approach for engaging students in computing: computational music remixing. The *EarSketch* project allows students to create unique music remixes while learning introductory computer science in an attempt to provide a relevant cultural context for computing that increases a student's sense of identity, belongingness, and creativity. Through several pilot studies, we have gained quantitative data supporting the effectiveness of *EarSketch*. However, we still do not know the underlying mechanisms that explain these results. For my research, I have conducted focus groups with students who have participated in an EarSketch pilot in order to better understand the ways in which *EarSketch* is affecting students' perceptions of and intention to persist in computing fields.

CHAPTER 1

INTRODUCTION

Computer science education is becoming more and more important in education. However, the field has much difficulty retaining students, especially underrepresented minority students such as females and African Americans. Reasons for this difficulty include inaccurate perceptions due to negative stereotyping and low motivation (Cheryan, Davies, Plaut, & Steele, 2009; Forte & Guzdial, 2005). If computer science education continues in its current state, by 2020, there will be 1 million more jobs for computer scientists than there are students enrolled in computer science degree programs("Bureau of Labor Statistics," 2012). There have been many attempts to engage students in computer science through outlets such as video games and animation (Wolz, Barnes, Parberry, & Wick, 2006). While these attempts have been well intentioned, they have not been quite as successful as hoped. My project will use the *EarSketch* project to explore the benefits of the integration of creative expression, constructionist principles, and authentic learning experiences through music remixing into the computer science classroom as they relate to student engagement, feelings of identity and belongingness, and, ultimately, to students' intention to persist in a computational field.

Previous Research

Introductory computer science courses are marked by low motivation, low grades, low participation by female and minority students, and misrepresentation within schools (Forte & Guzdial, 2005). How can we engage more students in computer science? "A key factor for engaging [students] with programming seems to be creativity"(Romeike, 2007).

Many women drop out of or fail to enroll in computer science courses due to the perception that these courses are overly technical and do not provide an outlet for creativity (Guzdial & Soloway, 2002). Studies have shown that, if given the ability to create, students show much higher motivation to learn (Gallagher, 2003). In a 2003 study, students who took part in an introductory computer science course that implemented some "creativity-teaching," were much more likely to describe computer science as being "fun" and "interesting" than were students who participated in a traditional introductory computer science course (Romeike, 2007).

What is Creativity?

There has been much argument regarding how creativity is defined and measured due to its highly subjective nature and distorted view by modern culture (Sternberg, 1999). Margaret Boden defines two different types of creativity: "h-creativity" and "p-creativity". H-creativity defines something that is historically novel and original. A new invention or the development of a new mathematical theorem might fall under this category. P-creativity defines something that is personally novel and original. The first time a student writes a computer program would fall under the category of p-creativity (Boden, 2004). P-creativity has also been defined as sublime and everyday creativity (Cropley, 2001). There are arguments against this structure that declare that "h-creativity" is the only kind of creativity and people that produce work as a result of this kind of creativity can be considered geniuses. Simonton (1999) argues that there is significant overlap between the two terms: creativity and genius. However, education, particularly at the K-12 and undergraduate levels, is interested in the ways that students are personally creative within their own individual learning, rather than in students' ability to generate something that is historically creative. Education strives to foster such "p-creativity" within the realm of the learning of different domains (Romeike, 2007). In his theory of constructionism, Papert argues that learning happens most effectively when making tangible, real-world objects (Harel & Papert, 1991). This type of creation is also where "p-creativity" emerges as students essentially build to learn.

Another understanding of creativity involves flow theory (Csikszentmihalyi, 1996). In this famous theory, Csikszentmihalyi describes a state called flow that he believes is necessary to creative thought and invention. Flow is described as a state in which a person is so immersed in a task that he or she loses concern for the self and all of his or her cognitive energy is focused on the task at hand. It is in this state that is possible for creative thought to emerge. According to Csikszentmihalyi, flow occurs when a person is confronted with a task that he or she believes can be completed, but is still sufficiently challenging and interesting. This task should have clear goals and immediate feedback. Many people can probably remember a time where they have entered a state of flow where they were so absorbed in their task that hours passed without notice.

Measuring Creativity

Because there is so much debate over defining creativity, measuring it can be difficult and, at times, ambiguous. Many means for measuring and evaluating creativity are called Creativity support tools (CSTs). Many CSTs involve gathering qualitative data from observational studies, interviews, and focus groups (Carroll, Latulipe, Fung, & Terry, 2009). There are occasionally surveys used to gather more quantitative data, but it is difficult to understand how accurate or helpful many of these surveys are.

One scale invented to measure levels of creativity as a result of various activities or programs is the Creativity Support Index (CSI) (Carroll et al., 2009). The CSI measures creativity in terms of feelings of exploration, expressiveness, immersion (flow), feelings of results being worth the effort of the task, enjoyment, and collaboration. When using this scale, participants fill out a Likert-type scale describing how much they agree or disagree to a variety of statements before filling out another survey in which they share what aspects of creativity are most important to them. This scale has been shown to have high test-retest validity and to be a useful way of measuring creativity, especially when combined with other methods.

Teaching Approaches

There are many different types of teaching approaches that are designed to promote creativity and experimentation amongst students. One such approach is the constructionist theory of education which holds that learning can happen most effectively when learners are actively creating tangible objects in the real world (Harel & Papert, 1991). The constructionist theory is inspired by the idea of constructivism, which is a theory that attempts to explain how new knowledge is constructed from preexisting knowledge(Harel & Papert, 1991; Papert, 1993). Constructionism falls under the category of active learning. Active learning is defined as any pedagogy that engages a student in the learning process (Prince, 2004). Studies that measure engagement in active learning environments have determined that it is more effective for students to construct knowledge on their own and to participate in the learning process than it is for students to passively absorb information transmitted by an instructor as in traditional lecture-style education (Prince, 2004). In one survey of how high school students spend their time, it was found that most high school students spend more than half of their time in school sitting through non-participatory instruction (Shernoff, Csikszentmihalyi, Schneider, & Shernoff, 2003). This has led to a decrease in student enjoyment and motivation, an effect which constructionism aims to bypass. There have been many teaching concepts developed around the idea of constructionism and active learning including the Montessori Method in which children learn concepts by working with tangible materials rather than being directly instructed (Montessori, 1912).

Constructionism is directly relevant to computer science and could be the key in fostering engagement and motivation within the field (Boyer, Phillips, Wallis, Vouk, & Lester, 2009). One problem posed by computer science education with regards to constructionism is that students begin a computer programming course with no effective model of a computer (Ben-Ari, 2001). Since constructionism is based on the idea that one builds new knowledge from related existing knowledge, the lack of a mental model of how a computer functions prevents true understanding of programming concepts, which merely seem abstract, intimidating, and unmotivating. One solution to this problem might be to begin introductory computer science courses with a detailed description of how computers work. Another solution might be to allow for students to develop an effective model of a computer by generating artifacts related to students' preexisting knowledge of things like music and games (Magerko, Freeman, McCoid, Jenkins, & Livingston, 2013; Resnick et al., 2009).

The idea of making computer science curriculum more personally relevant to students ties into the idea that learning experiences must be *authentic*. Primarily, the material must be authentic in that it can be applied to real-world situations and be personally relevant and engaging to the individual student. This kind of authenticity is considered to be "thick" authenticity (Shaffer & Resnick, 1999). There have been many programming languages and environments that have been developed to foster engagement through providing a curriculum that is personally relevant to students while also teaching them real-world computer science concepts such as algorithmic development and scripting. Some examples of such languages are Scratch, Alice and Logo (Cooper, Dann, & Pausch, Randy, 2000; Papert, 1993; Resnick et al., 2009). These languages work to make abstract programming concepts more concrete by allowing for them to be applied to concrete artifacts such as animations and music. Other developments in the field have worked toward a similar goal by building artifacts related to other areas, such as visual art (Kim, Coluntino, Martin, Silka, & Yanco, 2007), journalism (Wolz, Stone, Pulimood, & Pearson, 2010), digital games (Wolz et al., 2006), and social networks (Alt, Astrachan, Forbes, Lucic, & Rodger Susan, 2006).

Despite the existence of so many programming environments that foster creativity, motivation and authentic learning, computer science is very rarely mentioned directly within the context of constructionism (Romeike, 2007). I believe that combining constructivist and constructionist concepts with "creativity teaching" will foster motivation, engagement and retention. Studies have shown that an increase of student creativity and exploration in computer science courses is positively correlated to an increase in student retention (Lewandowski & Goldweber, 2005). However, despite the effect of creativity on student perceptions of computer science, curriculum that implements such practices leads students to a lower understanding of computer science principles as compared to traditional introductory computer science curriculum

(Romeike, 2007). The combination of a more structured curriculum that maintains the ideals of constructionism and active learning theories has the potential to work with creativity to help students understand the power and importance of computer science. While allowing students to work in creative environments fosters motivation and engagement, students and instructors alike must not forget the point of computer science. Computer science should not just be taught as a way to make music or to create games, but it should be presented as a subject that changes the way a person thinks and opens doors to achieving the seemingly impossible. This type of thinking is commonly referred to as "computational thinking." Computational thinking involves problem solving, system design, and understanding human behavior by means of drawing on the concepts that are fundamental to computer science (Wing, 2006).

EarSketch

EarSketch is a platform for computer science education involving computational music remixing as a foundation for the exploration of new teaching techniques for introductory computer science education (Magerko et al., 2013). *EarSketch* students are able to use Python code to manipulate audio samples and beats to create musical compositions. Because students are working at the high level of loops and beats, there is a low barrier of entry for learning to use *EarSketch.* In other words, students do not have to have formal training in music theory and music composition to use this program. As students learn basic programming principles, they can express themselves through controlling loops, rhythms, and effects to create unique musical compositions. There are three main components of *EarSketch*: the workspace, the curriculum, and the social media site.

Workspace

The workspace consists of two main parts. The first of these parts is a simple text editor development environment called Komodo in which students type their Python code. In their code, students call functions from the *EarSketch* API that perform actions such as placing music on a track, making beats, and adding effects. Students can choose what audio samples they would like to use from a library of files. Audio samples and beats were created to *EarSketch* by electronic artists, Richard Devine, and hip-hop producer, Young Guru.

After a student has written some code, he or she can then run it through Reaper, the second main component of the *EarSketch* workspace. Reaper is a Digital Audio Workstation (DAW). A DAW is a timeline-based software that allows users to place sound clips on tracks and add and manipulate effects. Reaper is comparable to software that is used in music production studios. When an *EarSketch* Python script is passed to Reaper, the composition described in the script is interpreted by and rendered on screen (Figure 1). Now the composition can be seen and heard.

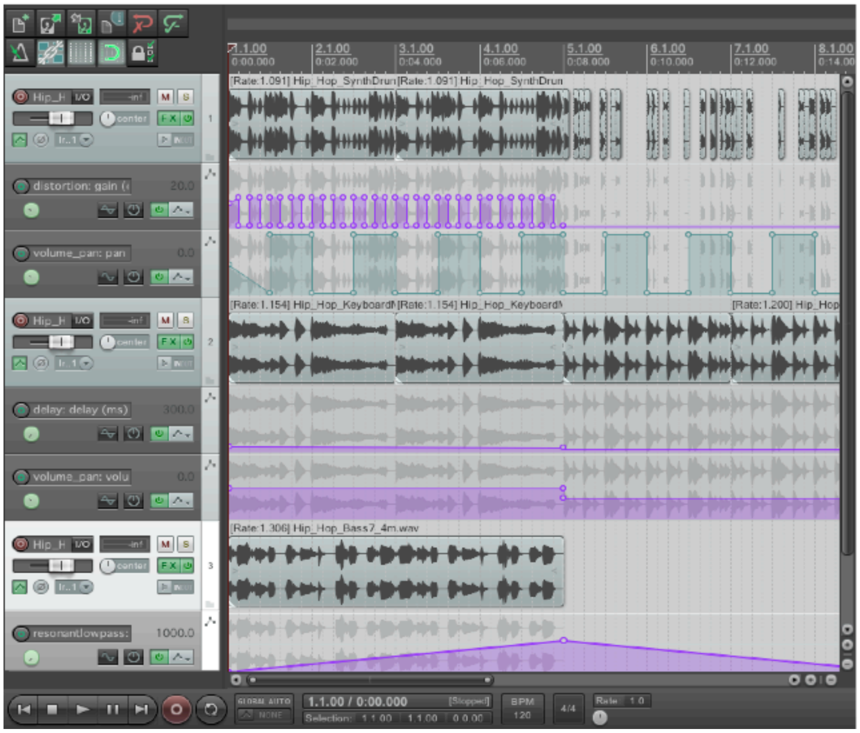

Figure 1. Example of a composition in Reaper

Below is an example of a simple *EarSketch* script. This script has three sections: the setup section, the music section, and the finishing section. The setup section is where the *EarSketch* library is imported and a brand new Reaper project is initialized. The tempo of the project is also defined in this section. The music section is where the code for the actual music composition can be found. In the example below, the variables used in the project are declared. These variables are constants that reference the sound files in the sound library. Then an API function called `fitMedia()` is called, which adds a loop to measures 1-4 on track 1. On track 2, a simple rhythm is defined and added to the composition using a beat string. Beat strings are strings composed of combinations of "+," "-," and "0." "0" tells the program to include a beat of music. "+" tells the program to sustain a beat, and "-" tells the program to rest. Each character represents one sixteenth note of a measure. In other words, a beat string that is 16 characters long will last for one measure. In the example below, we use a `for` loop to loop our measure-long rhythm for four measures. Finally, the finishing sections wraps up the project and includes any effects that were added.

```
from earsketch import *

#setup section
init()
setTempo(100)

#music section
piano = Y11_PIANO_1
drums = Y09_DRUM_SAMPLE_1
beatString = “0---0---0-0-0+++”

fitMedia(piano, 1, 1, 4)

for measure in range(1, 4):
    makeBeat(drums, 2, measure, beatString)

#finish section
finish()
```

Curriculum

The curriculum developed for *EarSketch* aims to teach introductory computer science material along with fundamental musical concepts such as musical structure and basic rhythm. The curriculum is grounded in concepts of “thick authenticity,” providing material that is meaningful and personally relevant to students. The curriculum was constructed based on topics of the CS Principles program, which is a national effort that aims to reach a wide and diverse audience of students and share with them the power and importance of computing during an introductory course (Astrachan & Briggs, 2012). Alignment with CS Principles was done to ensure that the curriculum would be applicable to high school Computer Science classrooms in the future. We chose to integrate *EarSketch* with the CS Principles program because their goals of having students collaborate and develop computational artifacts aligns well with our program.

As students learn to make music through programming, the curriculum urges them to understand the benefits and power of computer science. In addition, the curriculum emphasizes hands-on and collaborative experiences.

<u>Social Media Site</u>

Once a student has created an *EarSketch* composition that he or she is proud of, it can be uploaded to a social media site. The social media site is not only a place where students can show off their work, but listen to and look at projects that others have made. Students can even download projects from the social media site in order to make collaborative remixes.

EarSketch Pilot Studies

EarSketch has been piloted in two summer workshops with the Georgia Institute of Technology's Institute for Computing Education (ICE) organization. It has also been incorporated into Lanier High School's Computing in the Modern World course during Spring 2013, and in a Lanier High School Music Technology course in Fall 2013. During all pilot studies, students were asked to complete pretests and posttests to assess improvements in content knowledge. At the end of the pilots, students also completed retrospective attitude surveys in which they described attitudes before and after participation in *EarSketch* related to seven overarching psychosocial constructs:

1. Computing confidence (e.g. "I can get good grades in computing.")
2. Computing enjoyment (e.g. "I feel comfortable working with a computer.")

3. Computing importance/perceived usefulness (e.g. “I believe that it is very important for me to learn how to use a computer.”)
4. Motivation to succeed in computing (e.g. “I like solving computer problems.”)
5. Identity and belonging in computing (e.g. “I take pride in my computer abilities.”)
6. Intent to persist in computing (e.g. “I can see myself working in the field of computing.”)
7. Creativity in computing (e.g. “I am able to be very expressive and creative while doing computing.”)

Summer 2012 Workshop

During Summer 2012, the *EarSketch* curriculum, software, and social media site were piloted for the first time. The pilot workshop lasted for five days, with five hours of instruction in each day. The demographics of the group consisted of 18% Asian American, 24% African American, 53% European American, and 6% two or more races. The class was 75% male and 25% female (Magerko et al., 2013).

Retrospective attitude surveys showed statistically significant ($p < .01$) increases in attitudes in three of the seven psychosocial constructs: computing confidence, motivation to succeed in computing, and creativity (Table 1). Measurements for computer enjoyment and perceived importance/usefulness were high in both pre and post measures suggesting that the program students' positive perceptions of computing.

Table 1. Attitudes of workshop participants

Constructs		n	Mean[1]	Paired Samples *t-test*
Computing Confidence	Before	16	3.20	0.008**
	Now	17	4.11	
Computer Enjoyment	Before	17	4.31	0.838
	Now	17	4.34	
Computer Importance and Perceived Usefulness	Before	17	4.39	0.945
	Now	17	4.38	
Motivation to Succeed in Computing	Before	17	3.57	0.000**
	Now	17	4.03	
Computing Identity and Belongingness	Before	17	3.59	0.277
	Now	17	3.76	
Intention to Persist	Before	17	3.58	0.245
	Now	17	3.70	
Creativity	Before	17	3.46	0.006**
	Now	16	4.20	

Reference lines are set at 3.5 and 4. **p<.01; *p<.01; negatively worded items were reverse coded prior to mean computation of the constructs. Only students with matched before and now scores were assessed for statistical significance.

Further correlational analysis showed that, as students felt an increase in confidence, belongingness, and creativity, they felt a significant increase in their intention to persist in computing (Table 2). Additionally, confidence had a strong positive correlation with creativity, suggesting that the more creative a student is allowed to be in the classroom, the more confidence he or she feels with the material.

Table 2. Pearson correlation, n = 17

	Δ CKA overall	Δ Intent to Persist	Δ Confidence	Δ Enjoyment	Δ Importance & Perceived Usefulness	Δ Motivation	Δ Identity & Belongingness	Δ Creativity
Δ CKA (overall)	--							
Δ Intent to Persist	.083	--						
Δ Confidence	-.175	.583*	--					
Δ Enjoyment	.282	.093	.540*	--				
ΔImportance & Perceived Usefulness	.365	.366	.628**	.912**	--			
Δ Motivation	-.149	.431	.574*	.408	.364	--		
Δ Identity & Belongingness	.139	.740**	.815**	.646**	.839**	.507*	--	
Δ Creativity	-.242	.780**	.775**	.191	.333	.611**	.691**	--

**p<.01; *p<.05. Δ = Now-Before

The results of this study were positive, but concerning in that there was not a statistically significant increase in feelings of identity and belongingness as a result of participation in *EarSketch*, which is strongly correlated with intention to persist in the field. Figure 2 and Figure 3 show the expected correlations and the actual correlations obtained during the study. It is important to note that students who participated in the summer workshop elected to do so voluntarily. This means that most students were interested in computing or music before participating in *EarSketch*.

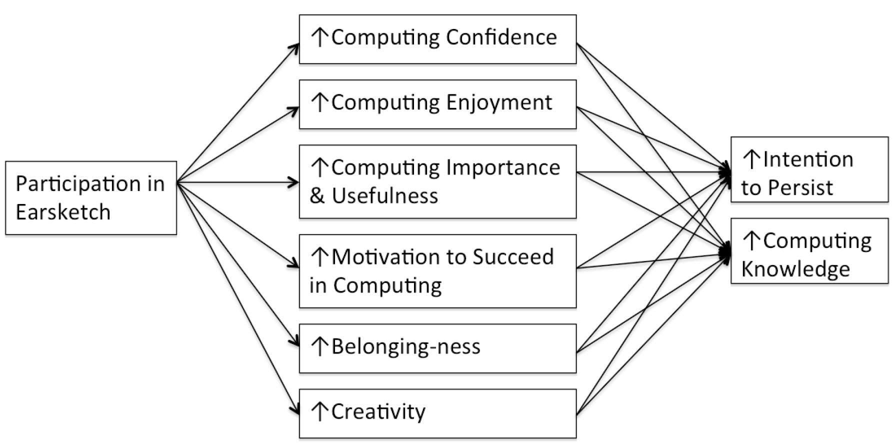

Figure 2. Expected correlations

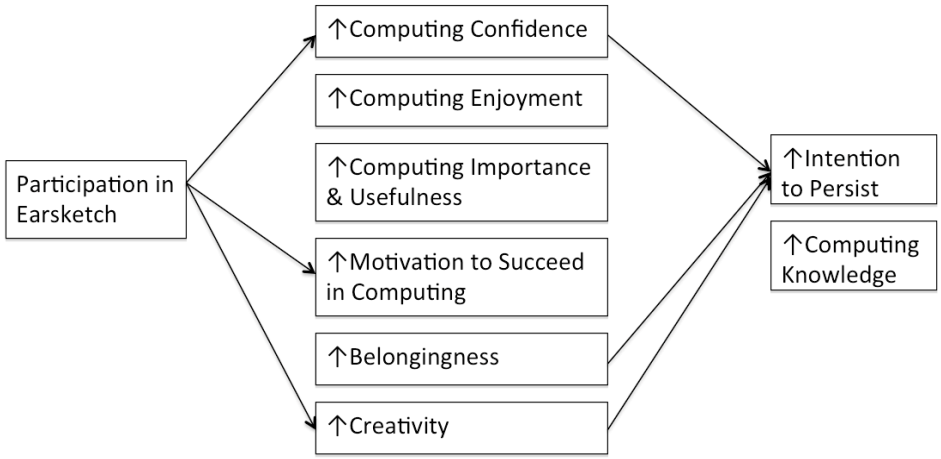

Figure 3. Actual correlations

Spring 2013 Lanier High School Pilot

During Spring 2013, *EarSketch* was piloted at Lanier High School over a six-week period (Magerko et al., 2014). Of all students at Lanier High School, 44% receive reduced or free lunches. *EarSketch* was taught to 69 students in a course titled "Computing in the Modern World." Of these students, 30% were female, 7% were Hispanic, and 16% were African American. Unlike the previous study, these students did not voluntarily elect to learn *EarSketch.* During the semester, Young Guru visited Lanier High School to watch the students working with *EarSketch* (Figure 4). It was motivating to students to see the importance and relevance of computer science in hip-hop music production.

Figure 4. A student (right) shares his EarSketch project with Young Guru (left)

Retrospective attitude surveys showed statistically significant ($p < .01$) increases in attitudes across all seven psychosocial constructs. Increases in attitudes were present across gender (Table 3) and ethnicity (Table 4). Interestingly, before participation in *EarSketch,* females showed significantly lower interest in computer science. After the program, female students reported having a similar level of engagement as males. There were also significant increases in the attitudes of both minority and majority students.

Table 3. Constructs by gender

	Female (n=21)				*Male (n=47)*			
Construct	*Before*	*Now*	*t-test*	*Effect Size*	*Before*	*Now*	*t-test*	*Effect Size*
Computing Confidence	2.58	3.88	<0.01**	1.95^{L}	3.00	3.99	<0.01**	1.26^{L}
Computing Enjoyment	3.74	4.29	<0.01**	0.93^{L}	3.79	4.36	<0.01**	1.05^{L}
Importance/ Perceived Usefulness	3.64	4.39	<0.01**	1.48^{L}	3.89	4.46	<0.01**	0.93^{L}
Motivation to Succeed	2.84	3.82	<0.01**	1.43^{L}	3.09	3.67	<0.01**	0.59^{M}
Identity and Belongingness	2.86	3.75	<0.01**	1.03^{L}	3.29	3.89	<0.01**	0.70^{M}
Intent to Persist	2.93	3.80	<0.01**	0.99^{L}	3.29	3.83	<0.01**	0.61^{M}
Creativity in Computing	3.19	3.86	<0.01**	0.89^{L}	3.33	3.93	<0.01**	0.73^{M}

Scale= 1, Strongly Disagree to 5, Strongly Agree. **p<.01, *p<.05, †p<.10. Negatively worded statements were reverse-coded to assess construct means. Effect size= (s) Small (0.20), (M) Medium (0.50), (L) Large (0.80).

Table 4. Constructs by ethnicity

	Minority (n=28)				*Majority (n=41)*			
Construct	*Before*	*Now*	*t-test*	*Effect Size*	*Before*	*Now*	*t-test*	*Effect Size*
Computing Confidence	2.95	4.05	<0.01**	1.48^{L}	2.82	3.90	<0.01**	1.41^{L}
Computing Enjoyment	3.75	4.30	<0.01**	1.02^{L}	3.79	4.36	<0.01**	1.03^{L}
Importance/ Perceived Usefulness	3.87	4.46	<0.01**	0.97^{L}	3.78	4.43	<0.01**	1.16^{L}
Motivation to Succeed	3.04	3.72	<0.01**	0.75^{M}	3.02	3.73	<0.01**	0.81^{L}
Identity and Belongingness	3.18	3.80	<0.01**	0.66^{M}	3.14	3.88	<0.01**	0.93^{L}
Intent to Persist	3.16	3.86	<0.01**	0.79^{M}	3.22	3.81	<0.01**	0.67^{M}
Creativity in Computing	3.41	4.02	<0.01**	0.84^{L}	3.21	3.84	<0.01**	0.76^{M}

Scale= 1, Strongly Disagree to 5, Strongly Agree. Assessment: Good=Above 4.0; Attention=Below 4.0; Action=Below 3.5. **p<.01, *p<.05, †p<.10. Negatively worded statements (n) were reverse-coded to assess construct means. Effect size= (s) Small (0.20), (M) Medium (0.50), (L) Large (0.80)

<u>Other Pilots</u>

EarSketch was piloted during a second summer workshop (Summer 2013) and a second term at Lanier High School (Fall 2013).

During all studies students were asked a number of free response questions at the conclusion of the pilot. Responses were overall positive. This was, however, the only qualitative data collected from the pilots. While an abundance of quantitative data has been obtained, it is difficult to fully understand the mechanisms behind the effectiveness of *EarSketch.* Because of this, I am setting out to collect qualitative data from students in order to understand the ways in which *EarSketch* engages students and the ways in which is can be improved.

CHAPTER 2

MATERIALS AND METHODS

Participants

Focus groups were comprised of Lanier High School students who took part in a Fall 2013 pilot. In total, 14 students, 4 female, 10 male, were sampled from class on a volunteer basis. Of the 14 students, 11 were African American. The students were enrolled in a music technology course. Students chose to take the course, indicating that they enjoy music to some degree.

Materials

Focus groups were conducted according to a specific protocol (Appendix A). The protocol targets the information that students were asked in their retrospective attitude surveys taken at the end of the pilot. More specifically, the protocol requests information about students' experience with *EarSketch*, and targets themes related to creativity, identity, and belongingness as they relate to a student's motivation, engagement, and intention to persist in computing.

Prior Experience

The first section of the focus group protocol requests information related to any programming experience that students might have had before participating in the *EarSketch* pilot. This allows for better differentiation between students who were interested in computing before the pilot and those who were not.

Experience with EarSketch

This section is intended to allow us to understand whether or not students felt as though they learned a lot through the *EarSketch* curriculum by asking about class projects and content. This section also tries to get at students' basic attitudes toward both programming and making music.

Creativity

Creativity questions were based on the Creativity Support Index (CSI) (Carroll et al., 2009). This scale measures creativity based on a set of constructs including results worth effort, expressiveness, exploration, immersion, enjoyment, and collaboration.

Identity and Belongingness

This section is aimed at understanding whether or not students felt as though they belonged in the computing field. Here we try to get at the connection between identity and belongingness and intention to persist by first asking whether or not students identify as computer scientists, and then asking them to reflect on the role computing might play in their future. Many of these questions are based on questions that students responded to in retrospective attitude surveys that were taken at the end of the pilot. This section is also retrospective in nature as it contains questions about what students feel that they might have changed as a result of participating in *EarSketch*.

Surveys

At the end of each focus group, participants filled out a single survey question asking for five words that best describe how they feel about programming.

Design

Two focus groups were conducted. The first focus group contained 8 students, while the second contained 6 students. Both groups contained a facilitator and a note taker. Both focus groups were audio recorded for richer data collection. Focus groups began with introductions and an explanation of how the study would work. After this preliminary section, the focus group protocol was followed.

Each question was asked and all students were encouraged to participate. If students were having difficulty responding to a question, the facilitator offered supplemental questions. Based on a student's answer to a question, the facilitator had the ability to ask another question to probe for more information. At the end of each focus group, students were asked to complete the survey question. Each focus group lasted 50 minutes and took place in a conference room located at Lanier High school. Focus groups took place during students' regular class time.

All focus group data was later transcribed and then analyzed using Dedoose, a qualitative data coding and analysis software.

CHAPTER 3

RESULTS

Results can be divided into seven major categories: identity, motivation, programmer conceptualization, intention to persist, immersion, confidence, and reflection.

Identity

When asked whether students would describe themselves as programmers to others, many said yes. However, some students pointed out that this self-identification depends on the person with whom they are speaking. For example, one student pointed out that she would be willing to describe herself as a programmer to a family member or friend, but not to another programmer. There was also noticeable variance in how students defined being a programmer. For example, one student stated, “I feel like I would describe myself as a coder because I am able to code what I’m thinking,” whereas a second student remarked, “I don’t think I’d label myself as a programmer because, even though I do like it, it’s not who I am as a person. I am just a person who likes to code and I can use code to make music or to make a website.” It seems as though these students describe themselves as having comparable abilities, but they identify differently. This could signify underlying effects of stereotypes and the varying ways that students define belonging to a group.

Motivation

Generally, female students tended to speak about being motivated more often. The survey question results revealed that females were significantly more likely to report feelings such as “motivated,” and “determined” with relation to programming. These results are indicative of quantitative results gathered from previous pilot studies (Magerko et al., 2014, 2013). Overall, there appears to be three different motivations for students to learn to program. The first is related to future opportunity. One female student said, “I didn’t realize how much it could get me a job that not a lot of people can get, or the fact that not a lot of girls do it. It just creates a lot of opportunity.” Interestingly, females were more likely than males to mention future career opportunities and the possibility of becoming a computer science major in college.

Another motivation that was mentioned frequently was the motivation to make not only music, but *good* music. Every student that participated in the focus groups mentioned the need to create something unique that he or she could be proud to show to others. One student mentioned how “sound quality is first over everything.” Another revealed, “The fact that you’re sitting there creating something, like a sound that someone might actually want to listen to, really distracts you. You just want to make it perfect every time you start something new.” This statement also brings to light the ways that the pressure to make something sound good can contribute to immersion. Some students even admitted to going back and fixing past class assignments and projects after they had been turned in to improve them.

The third motivation that surfaced during the focus groups was social pressure. This social pressure can be further divided into two different categories: pressure to not do badly, and pressure to be better than peers. This aligns with the concepts of performance avoidance and performance approach (Darnon, Harackiewicz, Butera, Mugny, & Quiamzade, 2007). When students are pressured to not do poorly, they are exhibiting performance avoidance goals. An example from the focus groups would be one female student who was worried about creating music that others would dislike. On the other hand, when students are pressured to outperform other students, they are exhibiting performance approach goals. Many students talked about feeling a sense of competition with their classmates. For instance, one student spoke about how seeing the projects of other students made her feel that she could “make it better,” and outperform her peers. These social effects seem to be created and facilitated by the social media site. This is interesting because the social media site was originally intended to promote collaboration rather than competition. Because students are required to post work on the social media site, a more competitive environment is perpetuated, causing students to engage with performance avoidance and approach goals. There did not appear to be a significant gender difference related to these paths of thought among students.

Programmer Conceptualization

During the focus groups, students were asked to talk about their own conceptualizations of computer scientists before and after learning EarSketch. Many of the initial descriptions signified a fundamental lack of knowledge about the field of computing. Male students tended to quickly mention programmer stereotypes such as “nerd,” “hacker,” or “plays video games.” Female students more openly expressed that they have no idea who computer programmers really are or what they do. The descriptions of how students saw programmers after learning EarSketch showed a more clear understanding of computing as a field. Additionally, students described programmers as being much more relatable. One student even remarked, “I’m a nerd now.” Overall, students seemed to have developed a more broad definition of a computer programmer. In some cases, students’ preconceptions of programmers remained, but the definition expanded. For example, when asked if she would describe herself to a friend as a computer programmer, one student said, “If I was telling someone who hasn’t coded before, they’d probably look at me like ‘What are you talking about?’ Like how you were saying before…like someone who hacks into computers. They wouldn’t understand. A programmer can also be someone who’s making music—like making a simple beat.”

Intention to persist

Among the students in both focus groups, intention to persist in computing was generally conditional. Many students only seemed interested in continuing programming if they were taking classes that involved material that was personally interesting to them. Some students did express unconditional interest in continuing their computer science education. Interestingly, the overwhelming majority of these students were female. Males, on the other hand, were more likely to state that they would only be interested in continuing to program if they were working with or creating music. This is predictable because every student had voluntarily enrolled in a music technology course, indicating that they enjoy music. However, this is interesting because it exemplifies a fundamental gender difference that has been recognized in other areas of research. Women tend to have more diverse areas of interest than men (Margolis & Fisher, 2003). In other words, women are more likely to adopt a variety of interests, whereas men tend to mostly adhere to a central interest. In this case, that central interest is music. Female students were much more willing to explore programming in new contexts than were male students.

Students who expressed interest in persisting in computing in college, or as a career, expressed interest in seeing how the concepts they are learning in EarSketch will help them in their future endeavors. To these students, the transfer wasn’t as clear as anticipated. Overall, it seems that it is very important for students to be making something concrete that they enjoy. One student, who had previously taken an AP Computer Science course stated that he didn't want to take another programming course, but "I actually kind of like it now because I'm actually doing something. Like I can actually know what I'm doing when I'm doing it. Instead of just writing blindly, I'm understanding." This statement shows the importance of authentic constructionist learning in intention to persist.

Immersion

There were numerous instances of students describing a sense of immersion when working with EarSketch. Many students directly described a state of flow (Csikszentmihalyi, 1996) where they are so immersed in their task that time passes without notice. Several students talked about how class seemed to go by incredibly quickly when they were working with EarSketch, whereas "every other class is like three hours." Students explained that they become so immersed within and focused on working in two different situations: when they are getting to work freely and are allowed to make whatever they want, and when they have a big project to work on. Students, particularly male students, seemed to be less engaged when working on smaller assignments. Interestingly, when looking at the survey questions, three different male students associated the word "focused" with programming. No female students reported words related to immersion.

Confidence

Quantitative results from our pilot study showed an increase in confidence across all groups, with females reporting greater increases than males. Based on qualitative data, all students reported gains in confidence, but females tended to speak about their newfound confidence much more enthusiastically. Females were also much more willing to admit how little they knew about programming at the beginning of the program. This possibly explains the lower reports of initial confidence in the attitude surveys. Additionally, in the survey question, males were significantly more likely to report negative feelings about programming like “stressful,” “confused,” and “frustrating.” On the other hand, females tended to list more words related to motivation like “determined” and “inspired.”

Reflection

Students tended to measure success in the program by the end quality of the music they created. In other words, the elegance of the actual code that they wrote meant less to them than the sound of the code’s output. This means of reflection probably contributed to the motivation for students to make good music.

CHAPTER 4

DISCUSSION

Results support EarSketch as being a motivating and engaging tool that helps students learn computing concepts, and helps transform students' conceptions of computer scientists. The results also indicate that EarSketch is effective with fostering student creativity and expression. All of this is consistent with the quantitative results received from the pilot studies. Notably, data showing significant confidence gains among female students were consistent with quantitative results. From the focus groups, we learned that one of the underlying mechanisms behind this confidence gain was an overwhelming lack of knowledge about the computing field, contributing to initial low confidence. The majority of students found programmers as being more relatable after using EarSketch. This indicates that students may be more willing to identify with computer scientists, leading to increased intention to persist.

An interesting finding from the focus groups is that EarSketch feels more authentic to students from a musical perspective rather than a programming perspective. Students recognize that they are learning to program, but they tend to see the transfer of programming into the music industry more strongly than the transfer into computing fields. Students who were interested in pursuing a future in programming even requested information that would allow them to see the link between EarSketch and university and industry programming. In order to fulfill this desire for more authenticity between EarSketch and computing fields, it would be helpful to incorporate more examples of transfer between the two different contexts within the curriculum. This could be in the form of links to external resources, or additional modules within the curriculum that make the connection clear.

There were some limitations to this study. First, our population consisted of students who had chosen to take a music technology course. This implies that most, if not all, of these students are primarily interested in music. These students came into class expecting to learn about music, not programming. Because of this, their personal motivations and goals are probably different than the average student taking an introductory computing course. That being said, it is also interesting that EarSketch was able to motivate students to persist in computing even though they had entered a presumably non-programming course. This supports EarSketch as an engaging tool that is able to motivate students to persist. Another limitation on the focus groups was that they had to be conducted in a very limited amount of time: a single class period. Since the students' class took place during first period, we also had to contend with school announcements and other interruptions before we could begin the focus groups. In the future, it would be useful to have more time to speak with the students.

The results present support for the effectiveness of an authentic STEAM learning environment. Students were very interested in the creative aspect of EarSketch and this promoted enjoyment and immersion in their tasks. After making the changes suggested by the present results, future focus groups can help us to evaluate progress and better understand the ways in which EarSketch works as an educational tool.

APPENDIX A

FOCUS GROUP PROTOCOL

Purpose:

The purpose of the EarSketch focus group protocol is to understand the relationship between participation in EarSketch and feelings of identity, belongingness, and creativity as they relate to perceptions of and intention to persist in computing.

Identity and Belongingness

- To what extent do students
- Identify themselves as computer programmers/computer scientists
- Feel that they belong in computer science
- Enjoy participating in class
- Enjoy attending class

Creativity

- To what extent do students
- Feel that they can express themselves through computing
- Enjoy computing
- See computing as a creative activity
- Feel that the results are worth the effort of programming
- See themselves as entering a state of flow while programming
- Feel that collaboration aids in creative expression in computing

Introduction:

Hi everyone, my name is Elise. I am a student at Georgia Tech working on the team that made EarSketch, which I hope that you have enjoyed using this semester.

(Introduce other present team members)

We are here to ask you about your experiences with EarSketch. We are asking for your feedback to help us understand how we can make EarSketch better.

So, let's go around the room and have everyone introduce themselves. When it's your turn, say your name and your favorite type of music.

(Introductions)

Before we begin, I have a couple of rules I want to go over.

- Firstly, it is important that everyone gets the chance to speak, so please speak up if you have something to say.
- We are looking for agreement and disagreement. So, if you agree with something someone else says, feel free to say that. If you disagree, tell us why.

- Secondly, it is important that only one person talks at a time. To help with this, I have this ball. When you are holding the ball, you can speak. When you are done speaking, pass the ball to the next speaker.

Questions:
Note: Bold questions are high priority questions

<u>Prior Experience:</u>

- Have you had any experiences with programming before you used EarSketch?
    - o *Have you used anything like Scratch or Alice? Have you made a web page?*

<u>Experience in EarSketch:</u>

- **If you explained to a friend what you did in Mr. Reilly's class, what would you say?**
    - See what kinds of information they highlight. Music? Programming?
- Explain the process you went through making an EarSketch project.
    - *How did you decide what kind of song you were going to make?*
- **What aspects of the program did you enjoy the most?**
    - Programming?
    - Music?
- Would you consider yourself more of a programmer or a musician? (segue to identity)

<u>Identity and Belongingness:</u>

- **Before learning EarSketch, describe who you thought computer programmers were. Do you feel any differently now?**
- Would you describe yourself to a friend as a programmer *(computer scientist)*? Why/why not?
- Think back to your first day learning EarSketch. How did you feel then compared to how you feel now about your potential to be a programmer?
    - *How did you feel about your ability to program at the very beginning?*
    - *How do you feel now?*
- Can you see yourself using programming in the future?
    - *In your future job? Or in college?*
- **If there were a class offered next year about programming, but without music, would you want to participate?**
    - **Why? Why not?**
    - *What kinds of things do you think you might be able to do with programming?*
    - *What would you want to learn?*

<u>Creativity</u>

- **What does the word creativity mean to you?**
    - **Based on your experience with EarSketch, can programming be a creative activity?**

        - *Use words from the answer to first question. Do you think EarSketch allows you to _______ or _______?*
    - Would you say that you feel creative when using EarSketch?
        - If yes, what specific aspects of EarSketch make you feel this way?
        - If no, why?
- Does getting to make music make you want to continue taking computer programming classes in the future?
- **Some students have said that, when they are programming, they are so focused that the rest of the world disappears—that they look up and see that a whole hour has passed.**
    - **Does this surprise you?**
- Now that you've finished your final project, would you do it all over again to make another song?
    - *Would you consider the efforts that you put into your project to be well worth what you got out of it (your song)?*
- What was your favorite part of making an EarSketch project?
- **Do you think that it was helpful to work with other students when creating music? If yes, why? If no, why not?**
- What are some things that you want to do that could be accomplished with programming?
    - *You've given lots of different examples. Can you think of anything you can't do with programming?*

<u>Additional Questions</u>

- What does it mean to you to be a programmer?
- How did you use the social media site?
    - *What did you like/dislike?*
- If given the opportunity, how would you improve EarSketch?
    - *What features would you like to see?*
- What did you think of the curriculum website?
    - *How would you improve it?*

Conclusion:
(Looks like we're running out of time) Does anyone have any last questions or comments?

Thank you so much for being involved—your feedback will be very helpful.

Timeline:
Focus group/s will be conducted with students after the completion of an EarSketch pilot study.

Reporting:
The report will be provided to all pertinent project personnel within 10-15 days of receipt of data.

Sampling Frame:
Focus group participants will be chosen from our current study population with a bias of gender on a volunteer basis.

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