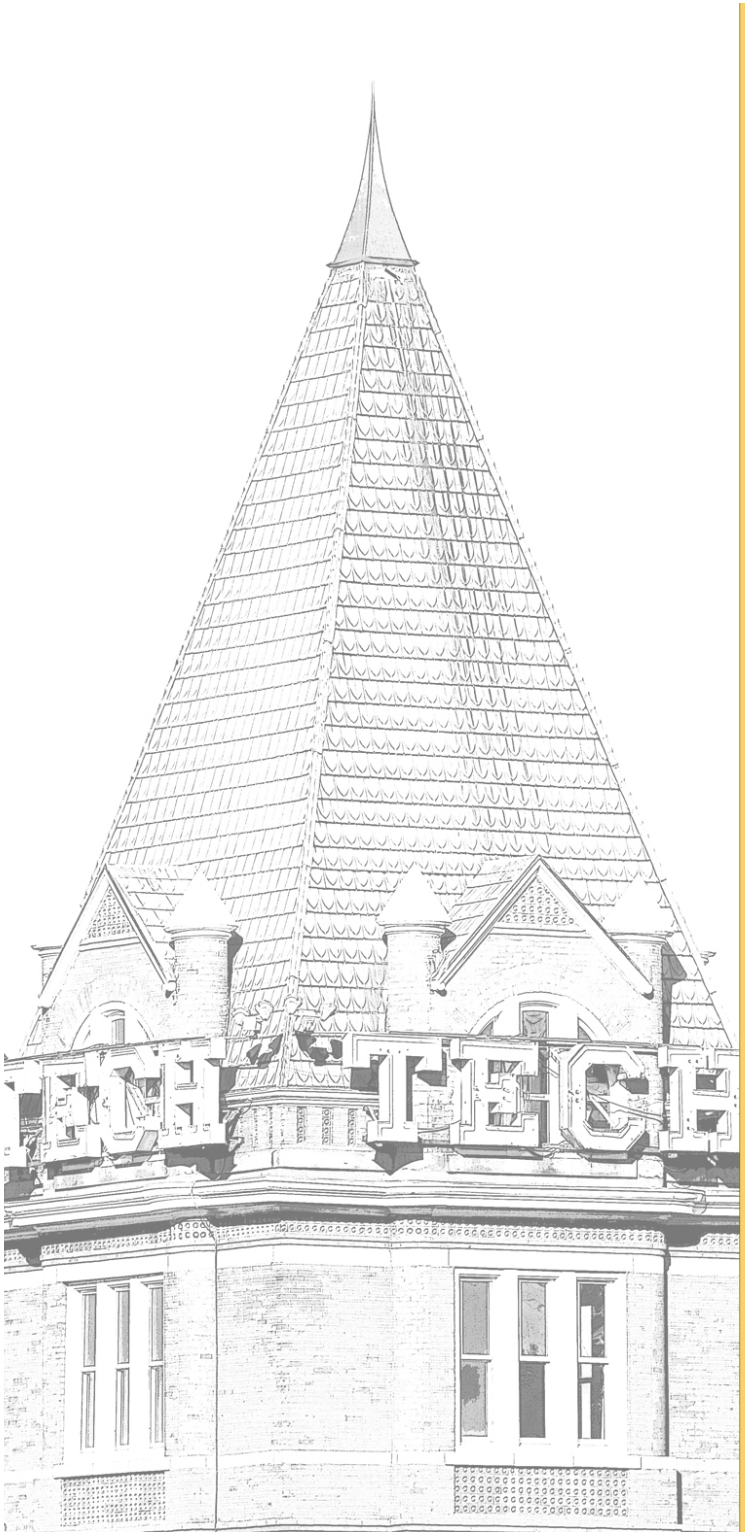


EarSketch: An Authentic STEAM Approach to Broadening Participation in Computer Science through Music

Jason Freeman
Associate Professor
School of Music

Georgia Institute of Technology

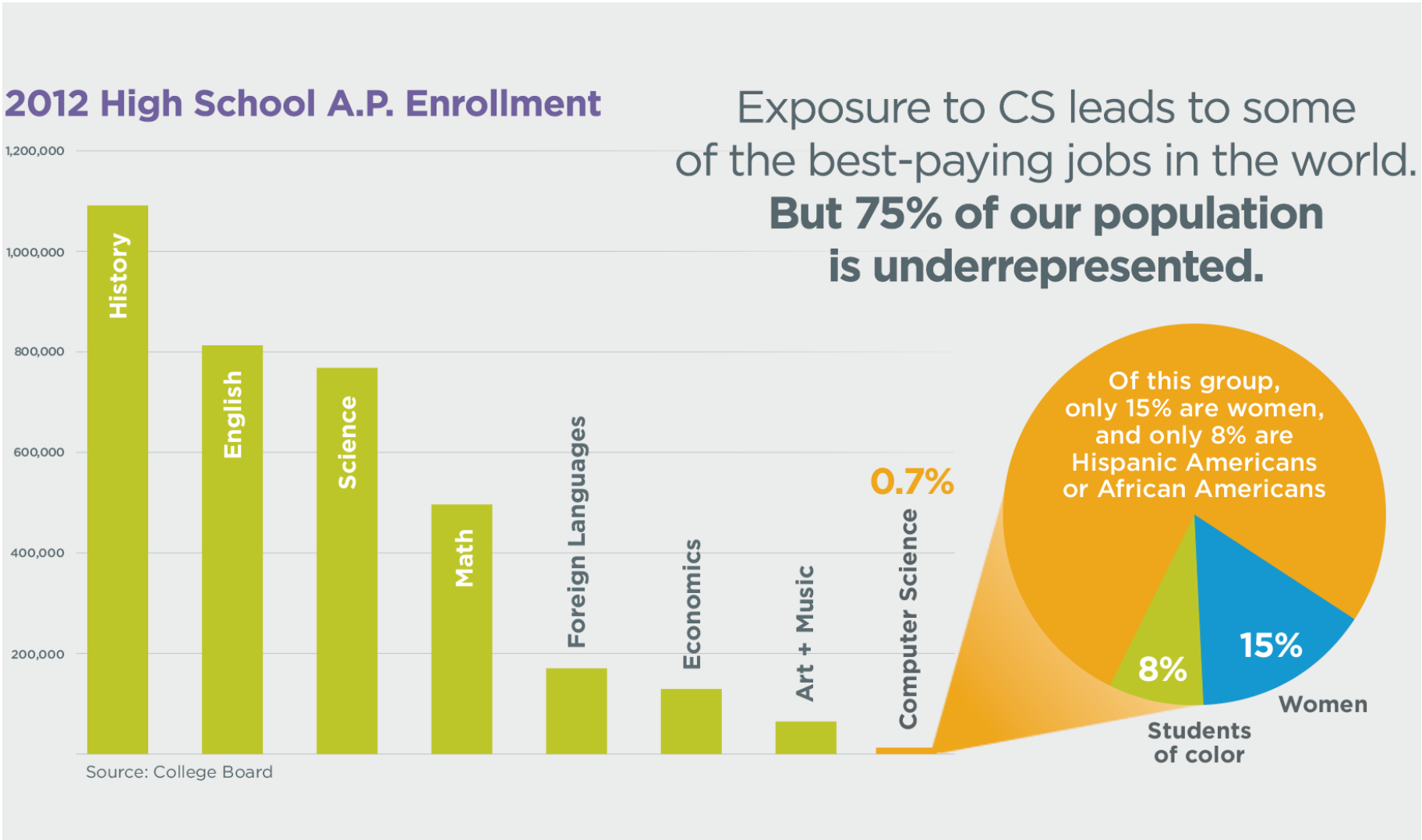
ABOUT ME

ABOUT GEORGIA TECH

1. Broadening Participation in Computing
2. Broadening Access to Music Technology Education
3. Evangelizing Music Making with Technology

MOTIVATIONS FOR EARSKETCH

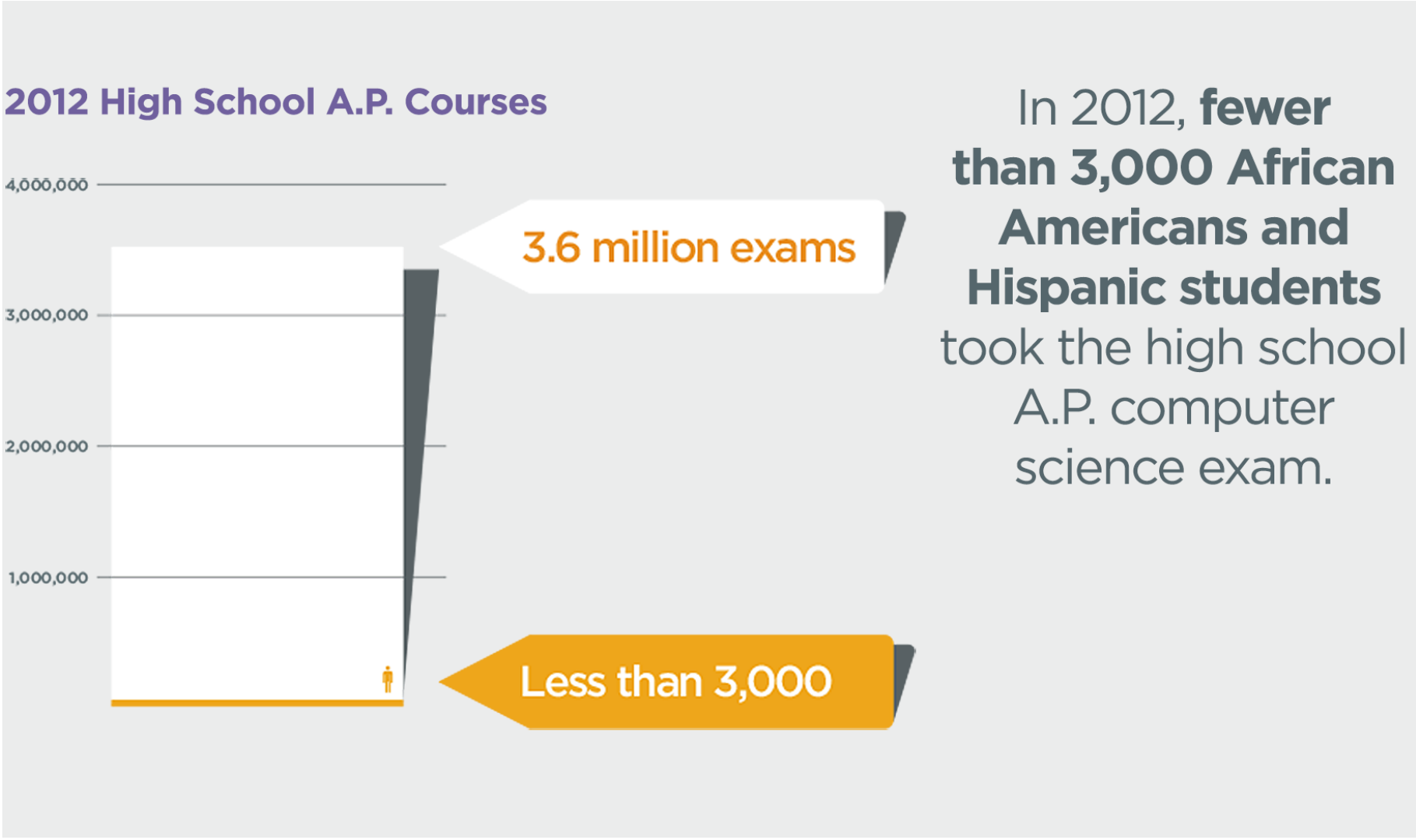
BROADENING PARTICIPATION IN CS



Source: Code.org

BROADENING PARTICIPATION IN CS

Georgia Tech



Source: Code.org

BROADENING PARTICIPATION IN CS

Georgia Tech

Gender Inequity

While, 57% of bachelor's degrees are earned by women, **just 12% of computer science degrees** are awarded to women.

Source: Code.org

BROADENING PARTICIPATION IN CS

Georgia Tech

Our Hypothesis:

A STEAM approach to introductory computing eduation that is authentic and culturally relevant in both computing and music domains will engage a more diverse population of students in computing.

A “CLASSIC” INTRO CS ASSIGNMENT

Georgia Tech

“Now let's take what we've learned so far and write a Pig Latin translator.

Pig Latin is a language game, where you move the first letter of the word to the end and add "ay." So "Python" becomes "ythonpay." To write a Pig Latin translator in Python, here are the steps we'll need to take:

Ask the user to input a word in English.

Make sure the user entered a valid word.

Convert the word from English to Pig Latin.

Display the translation result.”

(Source: https://www.codecademy.com/)

A SAMPLE EARSKETCH ASSIGNMENT

Compose a song using to the requirements below.

The Basics

Length: 24 measures or longer

Tempo: any

The Structure

The composition should have A and B sections. Repeat these sections three times (ABABAB)

Intros and outros can be added, but are not required

The Code

Use fitMedia() in at least one of the sections.

Use makeBeat() in both A and B sections.

Use at least one *for* loop

Use at least one conditional ("if") statement

Use one or more effects on at least one track.

Add comments to describe all of your work in the items above (identify musical sections, point out required API function calls, etc.)

1. Broadening Participation in Computing
2. **Broadening Access to Music Technology Education**
3. Evangelizing Music Making with Technology

MOTIVATIONS FOR EARSKETCH

BROADENING ACCESS TO MUSIC TECH

Georgia Tech

“The MIDI Class”

Source: UTEMS (UT Austin)

BROADENING ACCESS TO MUSIC TECH

EarSketch as:

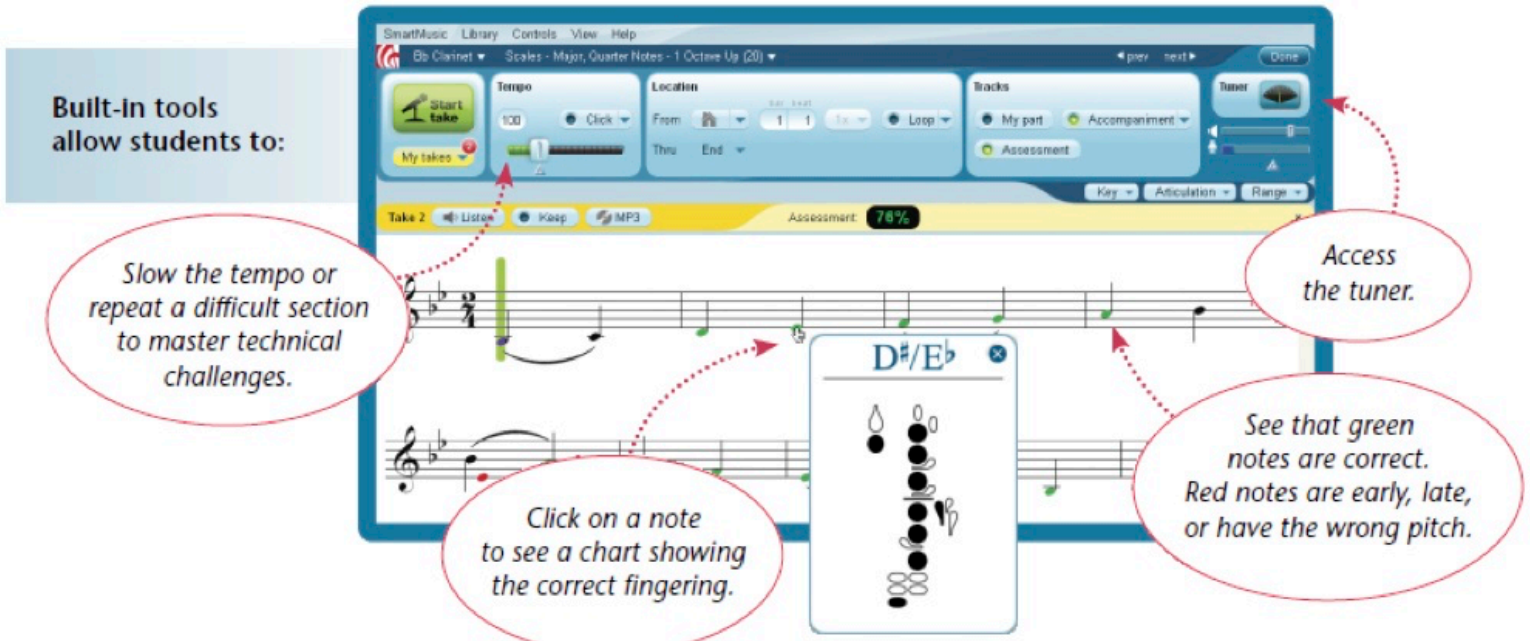
1. An environment that can help transition intro music tech courses away from dedicated studio space.
   - Integrated DAW + algocomp approach
2. A way to bring music technology into the computing classroom.

1. Broadening Participation in Computing
2. Broadening Access to Music Technology Education
3. **Evangelizing Music Making with Technology**

MOTIVATIONS FOR EARSKETCH

EVANGELIZING MUSIC MAKING

- No one makes music anymore:
  - 12% of American adults play an instrument at least once per year (Source: NEA).
- Music is rarely taught to children as a creative practice



Source: SmartMusic

EVANGELIZING MUSIC MAKING

- EarSketch as “sneaky” music education
  - Not taught by music teachers
  - No presumption of music skills / knowledge
  - Focus on creativity and personal expression

1. Broadening Participation in Computing
2. Broadening Access to Music Technology Education
3. Evangelizing Music Making with Technology

MOTIVATIONS FOR EARSKETCH

THE BASICS OF EARSKETCH

WHAT IS EARSKECH?

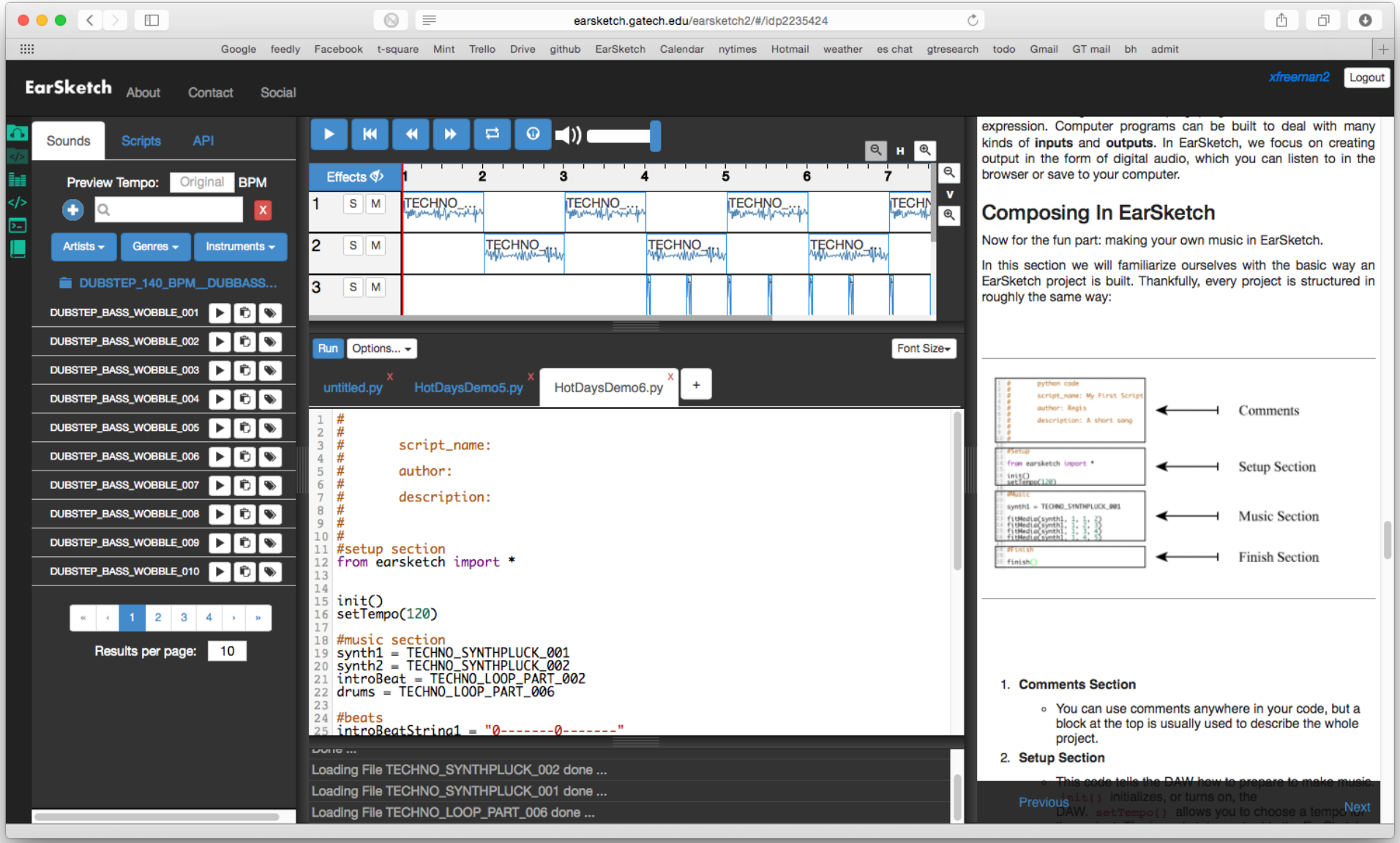
- Project initiated at Georgia Tech in 2011
- Interdisciplinary team:
  - Music composition / production / technology
  - Digital Media
  - CS education
  - Human-computer interaction
  - Evaluation and Analysis
  - Etc.

WHAT IS EARSKETCH?

EarSketch is a STEAM learning environment that engages students by teaching introductory computer science in the context of music composition, remixing, and production.

WHAT IS EARSKETCH?

- Digital audio workstation
- Coding environment for Python or JavaScript
- Audio Loop Library
  - Richard Devine & Young Guru
- Curriculum for intro CS


earsketch.gatech.edu/earsketch2/#/idp2235424
EarSketch
About
Contact
Social
xfreeman2
Logout
Sounds
Scripts
API
Preview Tempo:
Original
BPM
Artists
Genres
Instruments
DUBSTEP_140_BPM__DUBBASS...
DUBSTEP_BASS_WOBBLE_001
DUBSTEP_BASS_WOBBLE_002
DUBSTEP_BASS_WOBBLE_003
DUBSTEP_BASS_WOBBLE_004
DUBSTEP_BASS_WOBBLE_005
DUBSTEP_BASS_WOBBLE_006
DUBSTEP_BASS_WOBBLE_007
DUBSTEP_BASS_WOBBLE_008
DUBSTEP_BASS_WOBBLE_009
DUBSTEP_BASS_WOBBLE_010
Results per page: 10
Effects
Run
Options...
Font Size
untitled.py
HotDaysDemo5.py
HotDaysDemo6.py
#
script_name:
author:
description:
#
#setup section
from earsketch import *
init()
setTempo(120)
#music section
synth1 = TECHNO_SYNTHPLUCK_001
synth2 = TECHNO_SYNTHPLUCK_002
introBeat = TECHNO_LOOP_PART_002
drums = TECHNO_LOOP_PART_006
#beats
introBeatString1 = "0-------0-------"
Loading File TECHNO_SYNTHPLUCK_002 done ...
Loading File TECHNO_SYNTHPLUCK_001 done ...
Loading File TECHNO_LOOP_PART_006 done ...
expression. Computer programs can be built to deal with many kinds of inputs and outputs. In EarSketch, we focus on creating output in the form of digital audio, which you can listen to in the browser or save to your computer.
Composing In EarSketch
Now for the fun part: making your own music in EarSketch.
In this section we will familiarize ourselves with the basic way an EarSketch project is built. Thankfully, every project is structured in roughly the same way:
Comments
Setup Section
Music Section
Finish Section
1. Comments Section
◦ You can use comments anywhere in your code, but a block at the top is usually used to describe the whole project.
2. Setup Section
Previous
Next

KEY DESIGN GOALS

- Authentic
  - Industry-standard programming languages
  - Industry-standard DAW paradigms
- Culturally relevant
  - Audio library from music industry veterans
  - 20+ popular music styles
  - Record and upload your own content
- No prior experience needed
  - No music theory, notation, MIDI-like paradigms
  - No coding skills

WHERE EARSKETCH?

- high school students
  - Introductory computing courses
  - Summer camps
- college-level courses (intro CS)
- teacher training

25,000 students from 50 states & 100+ countries

CURRICULUM OVERVIEW

Georgia Tech

Computing concepts:

- Data types, variables, constants, functions
- Loops
- Conditionals and boolean logic
- Abstractions (functions)
- data structures (arrays)
- Randomness
- String and list operations

CURRICULUM OVERVIEW

Music:

- DAW basics
- Tempo, meter, rhythm
- Musical Form (i.e. ABA)
- Repetition, contrast, randomness
- Copyright, creative commons, fair use
- Music Information Retrieval

API OVERVIEW

- Place audio on multi-track timeline
- Step-sequence rhythms from strings
- Place effects on tracks and automate parameter changes
- Extract features from audio files

IMPLEMENTATION OVERVIEW

- Entirely browser-based application
  - School lab deployment
- Client: JS, Web Audio API, Angular, etc.
- Server: Tomcat + MySQL
  - Lightweight; almost everything happens on client

CODE EXAMPLES (PYTHON)

Georgia Tech

Basic demo

Simple declarative style

Step sequencing with strings and lists

Sonification and list traversal

Audio analysis and conditionals

Recursion and fractals

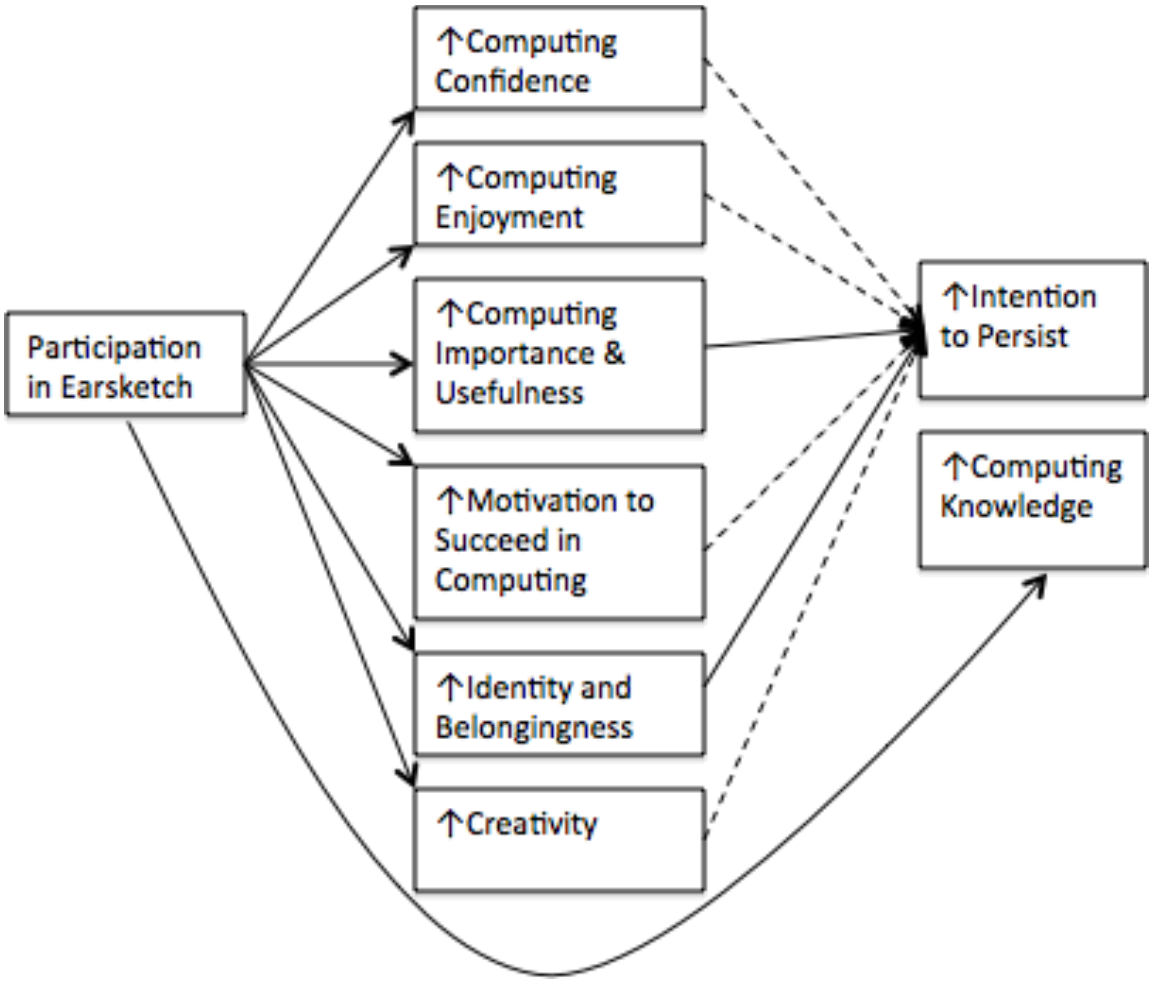
Actual student project

RESEARCH FINDINGS

METHODOLOGY

- 98 students at metro-Atlanta high school
  - 43% minority, 27% female
- Intro Computing / Intro Music Tech courses
- 10+ week EarSketch module
- Pre-post content knowledge assessment
- Pre-post computing attitudes survey
- Focus groups

THEORY OF CHANGE



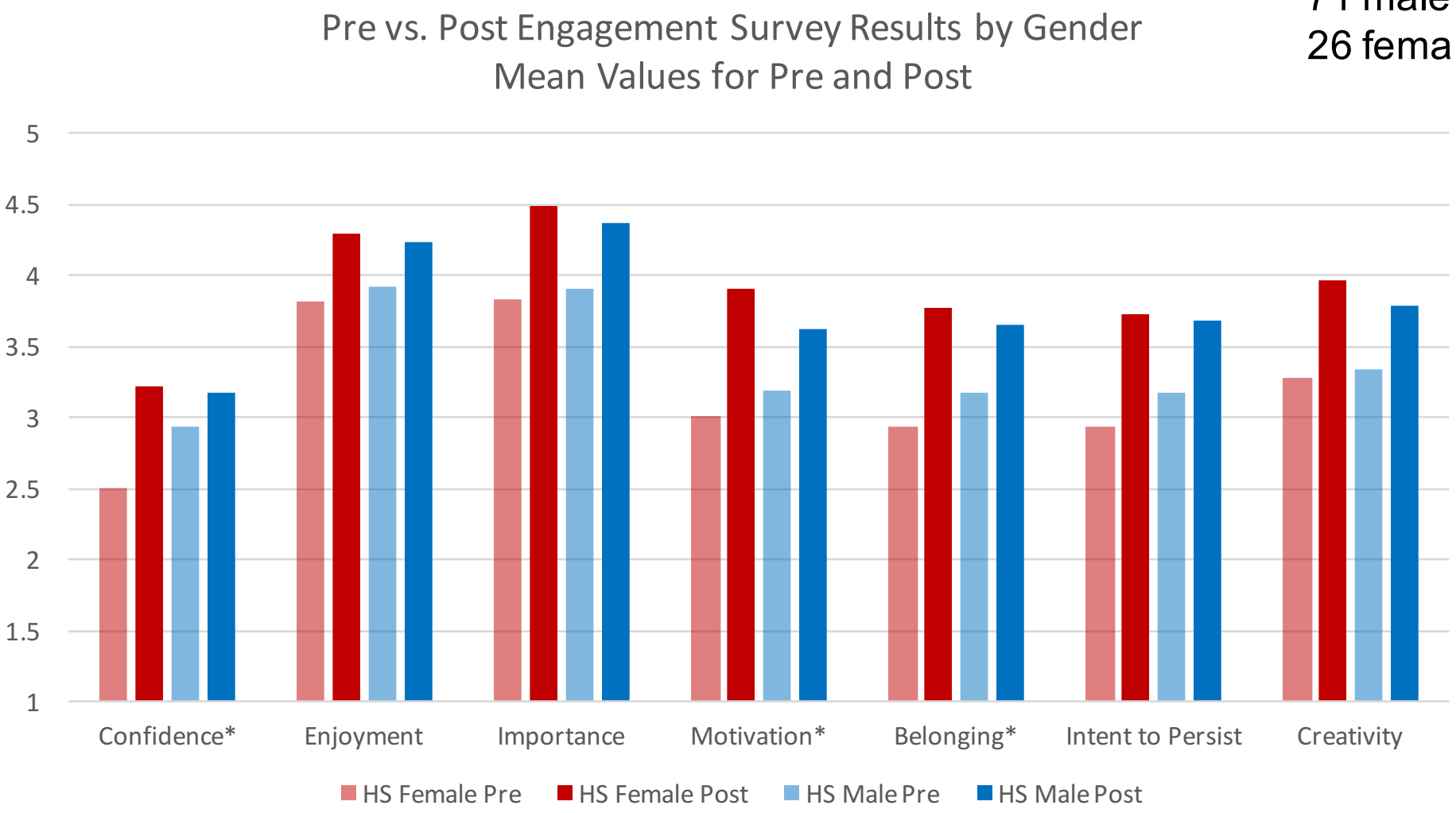
CONTENT KNOWLEDGE

- Statistically significant increases from pre to post across all populations

- No significant differences in gains between populations

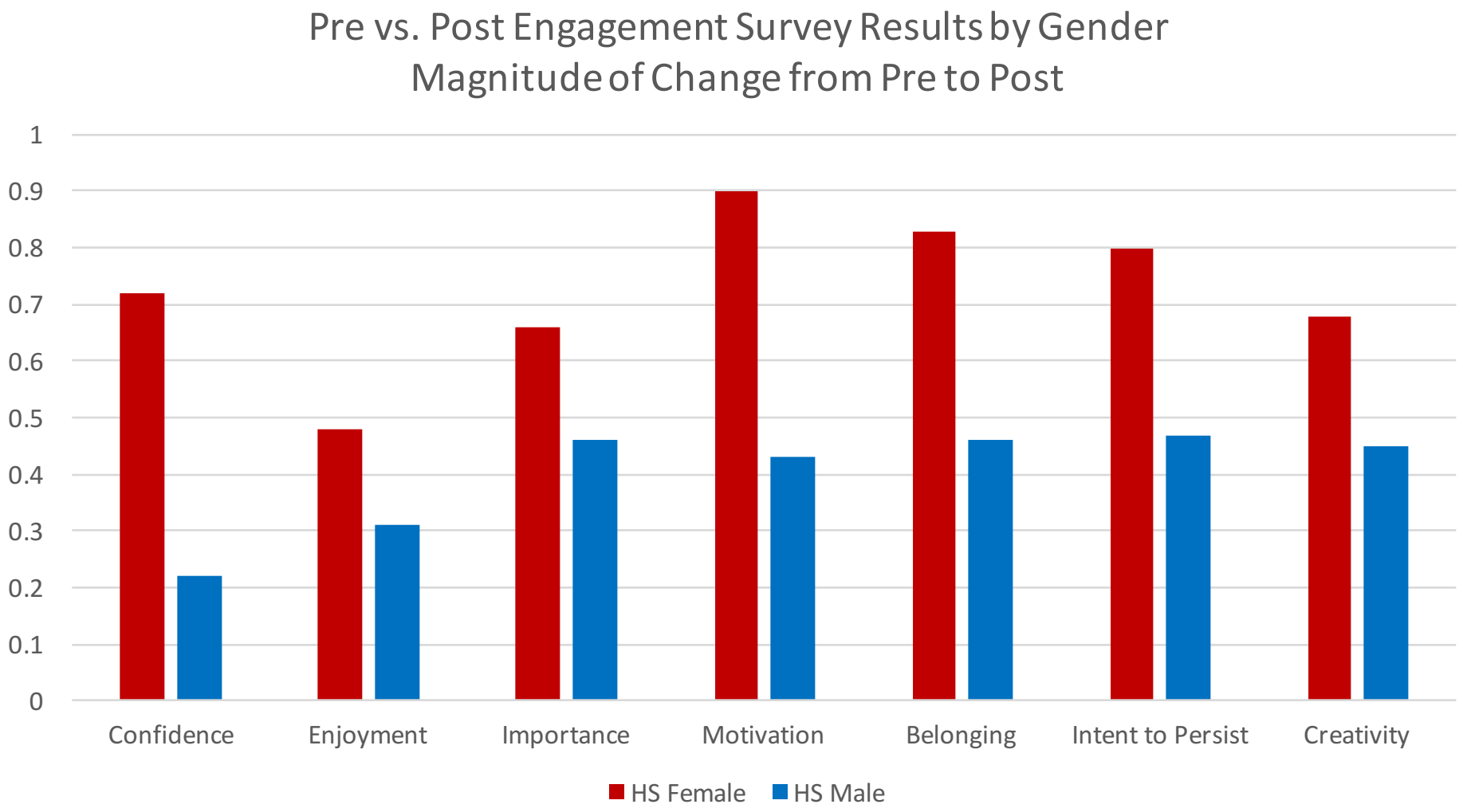
MALE VS. FEMALE ENGAGEMENT

71 male
26 female



$p < 0.001$ for pre-to-post within gender for all constructs except male confidence ($p=0.07$).
Gender comparison t-test $p < 0.05$ for confidence, identity and belongingness, and motivation.

MALE VS. FEMALE ENGAGEMENT



STUDENT COMMENTS

"I got to express my ideas and it was fun and inspiring to see that I could be good at computing."

"I liked learning how music is made and how we can learn and get good at doing things that people in the music industry do now."

"I enjoyed making my own music tracks that people, including myself, actually liked."

"It gives me choices for college. Like this is something I would actually like to do for college and I'd actually like to do probably with my life. Yeah. I would love to do it."

Coursera, the largest MOOC provider, has over 14 million students taking over 1000 courses.

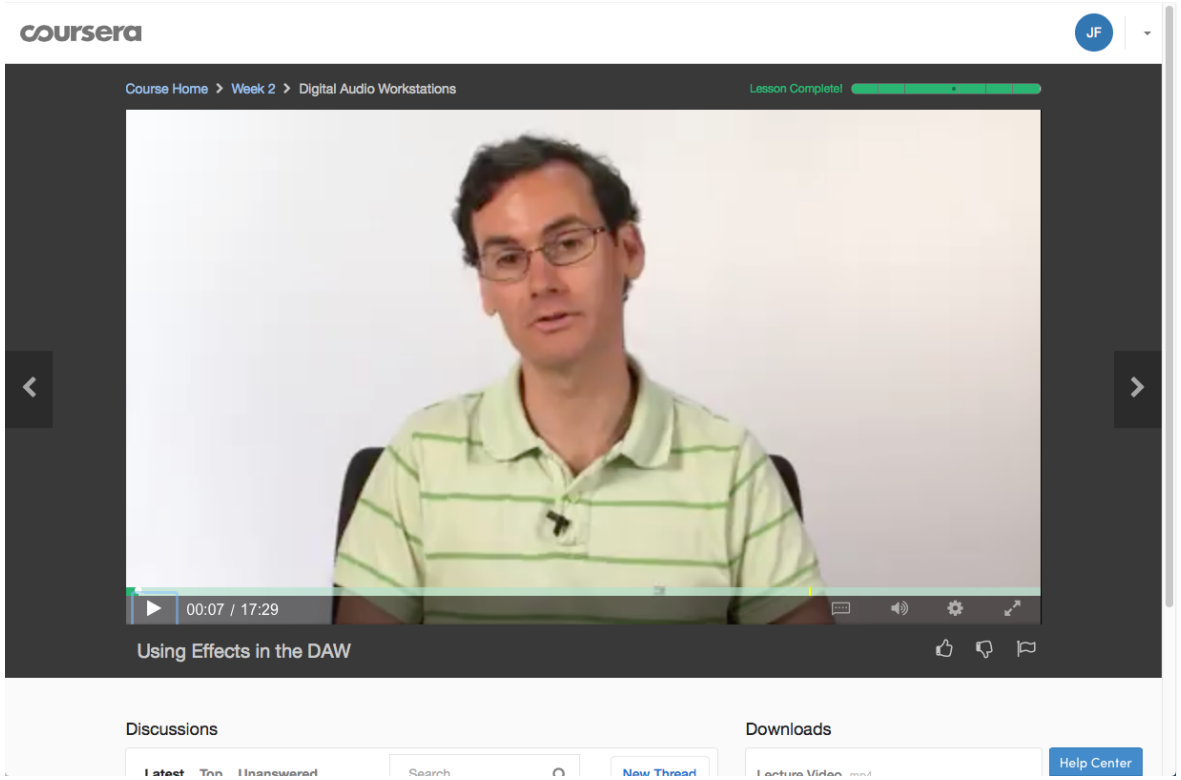
MASSIVE OPEN ONLINE COURSE (MOOC)

SURVEY OF MUSIC TECHNOLOGY

6-week intro music technology course

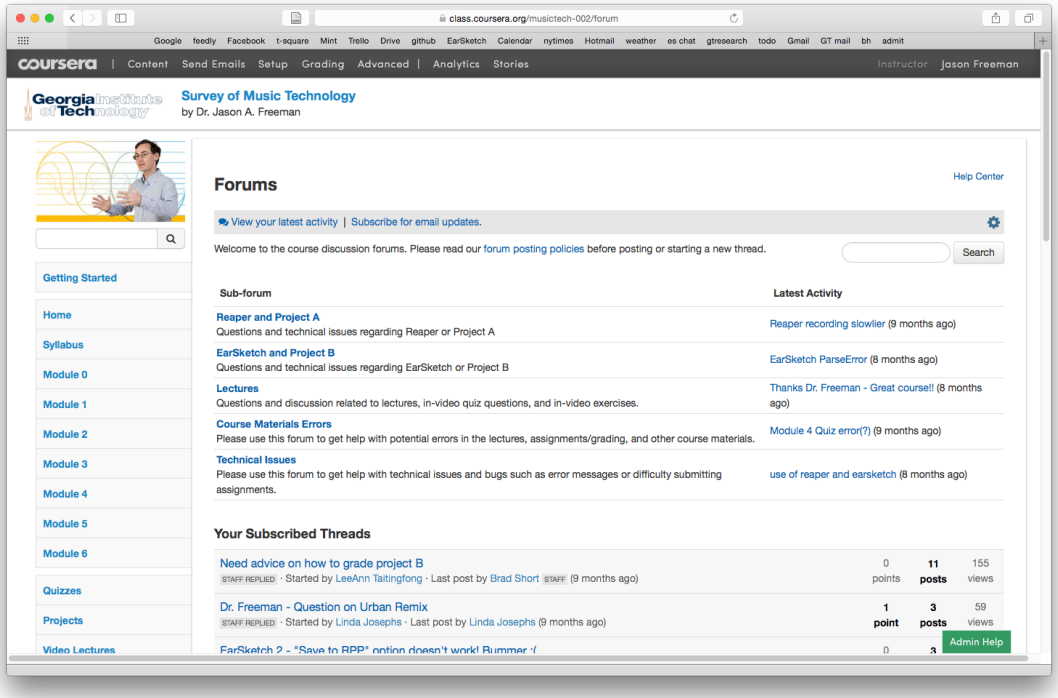
Coursera

First offered 2013, now in third iteration



STRUCTURE

- Video lectures
- In-video quizzes and exercises
- Auto-graded Quizzes
- Peer-reviewed Projects
- Discussion Forums



- Content:
  - DAWs (Reaper)
  - Computational Music (EarSketch)

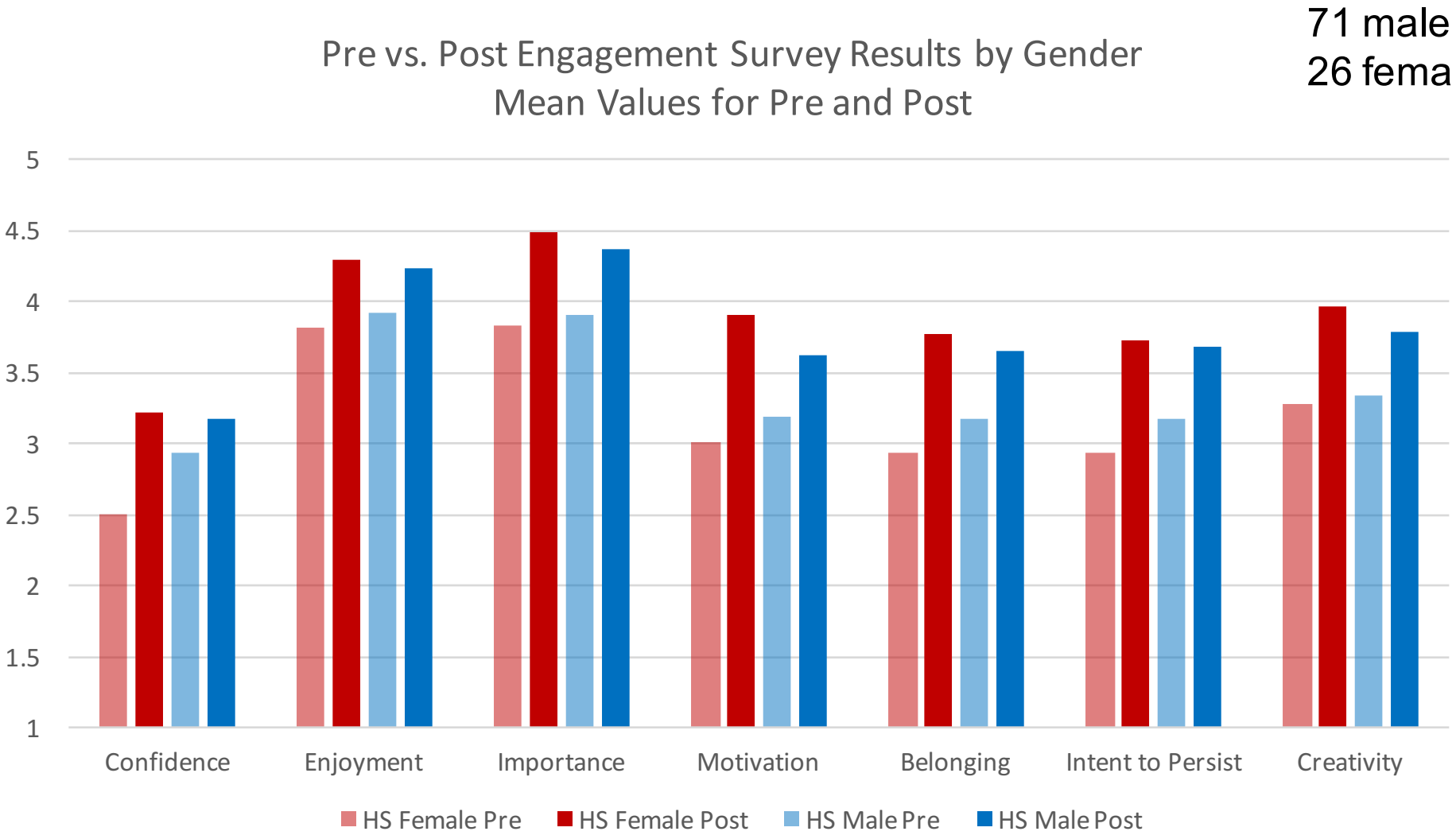
IS IT THE SAME?

- What stays:
  - Open-ended creative and expressive projects
  - Authentic and culturally relevant
- What goes:
  - Limited peer interaction (forums, peer grading)
  - Limited instructor interaction
  - Limited learning environment
- Students of all ages, experiences, intents

ARE STUDENTS STILL ENGAGED?

HS DATA

71 male
26 female



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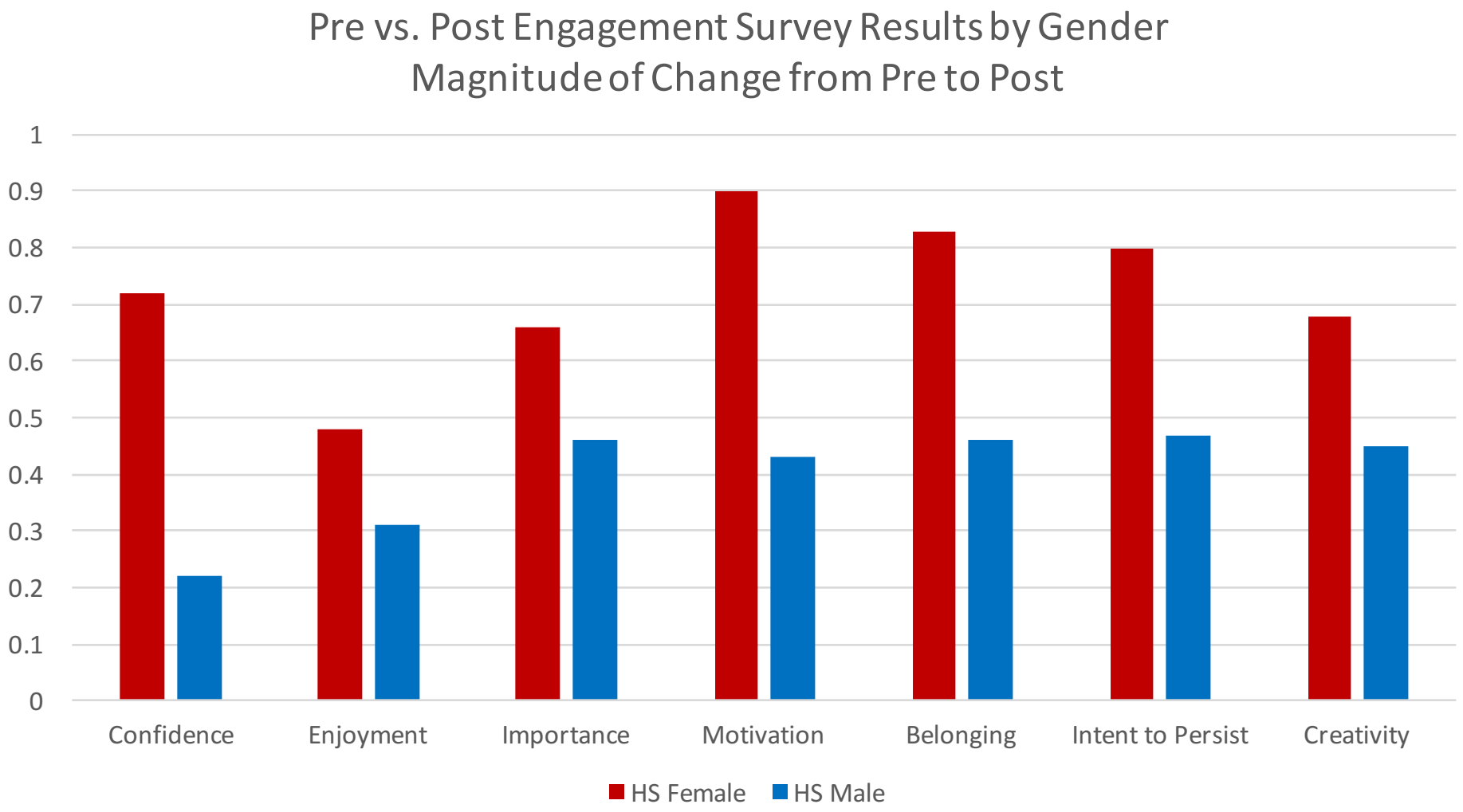
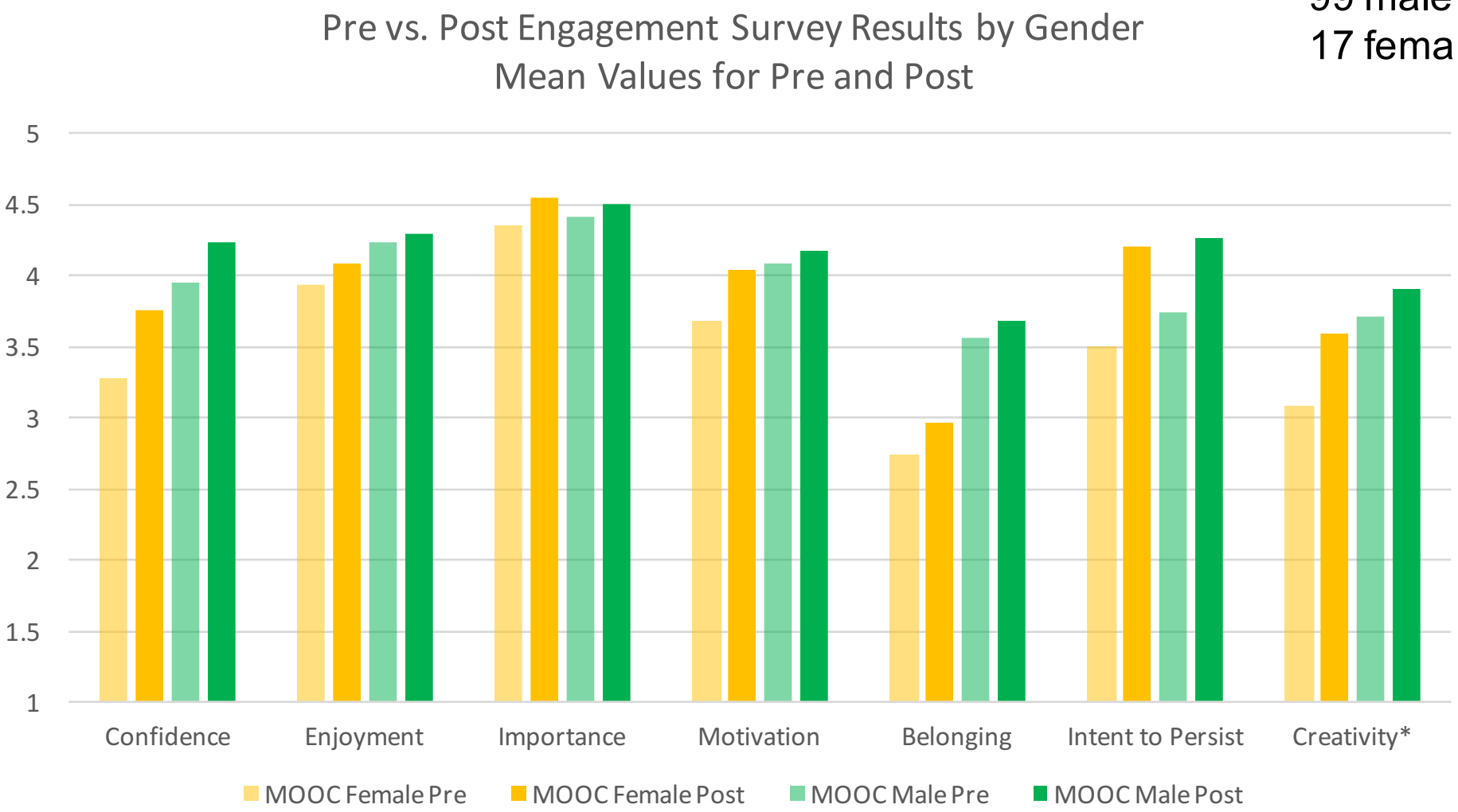
Gender comparison t-test $p < 0.05$ for confidence, identity and belongingness, and motivation.

HS DATA


Pre vs. Post Engagement Survey Results by Gender
Magnitude of Change from Pre to Post
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Confidence
Enjoyment
Importance
Motivation
Belonging
Intent to Persist
Creativity
HS Female
HS Male

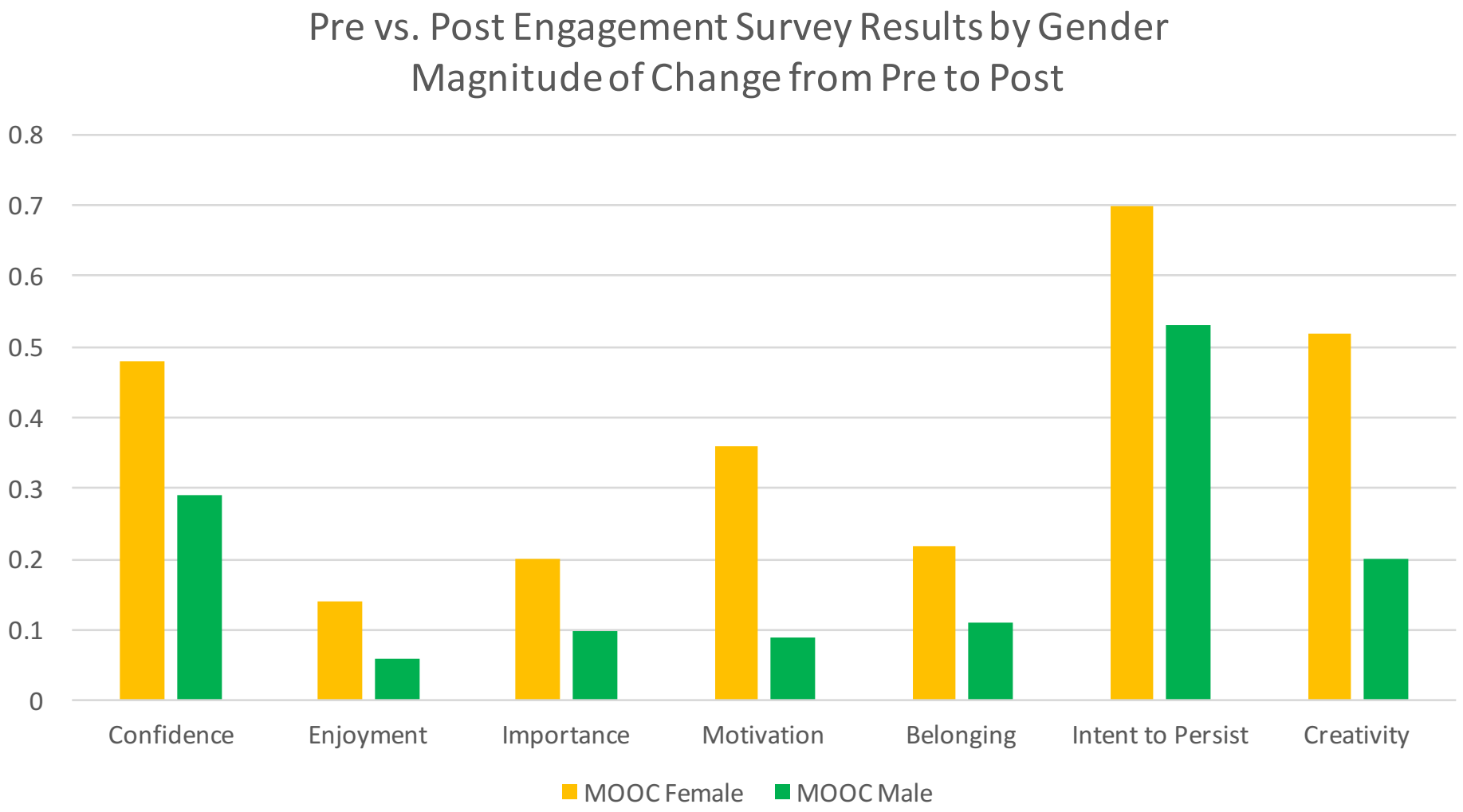
MOOC DATA

99 male
17 female



Significance at $p < 0.001$ for pre-to-post within gender for all constructs for males except motivation ($p = 0.002$). Significance for females for confidence (0.018), identity (0.007), intent to persist (0.001), and creativity (0.001).
Gender comparison t-test $p = 0.03$ for creativity.

MOOC DATA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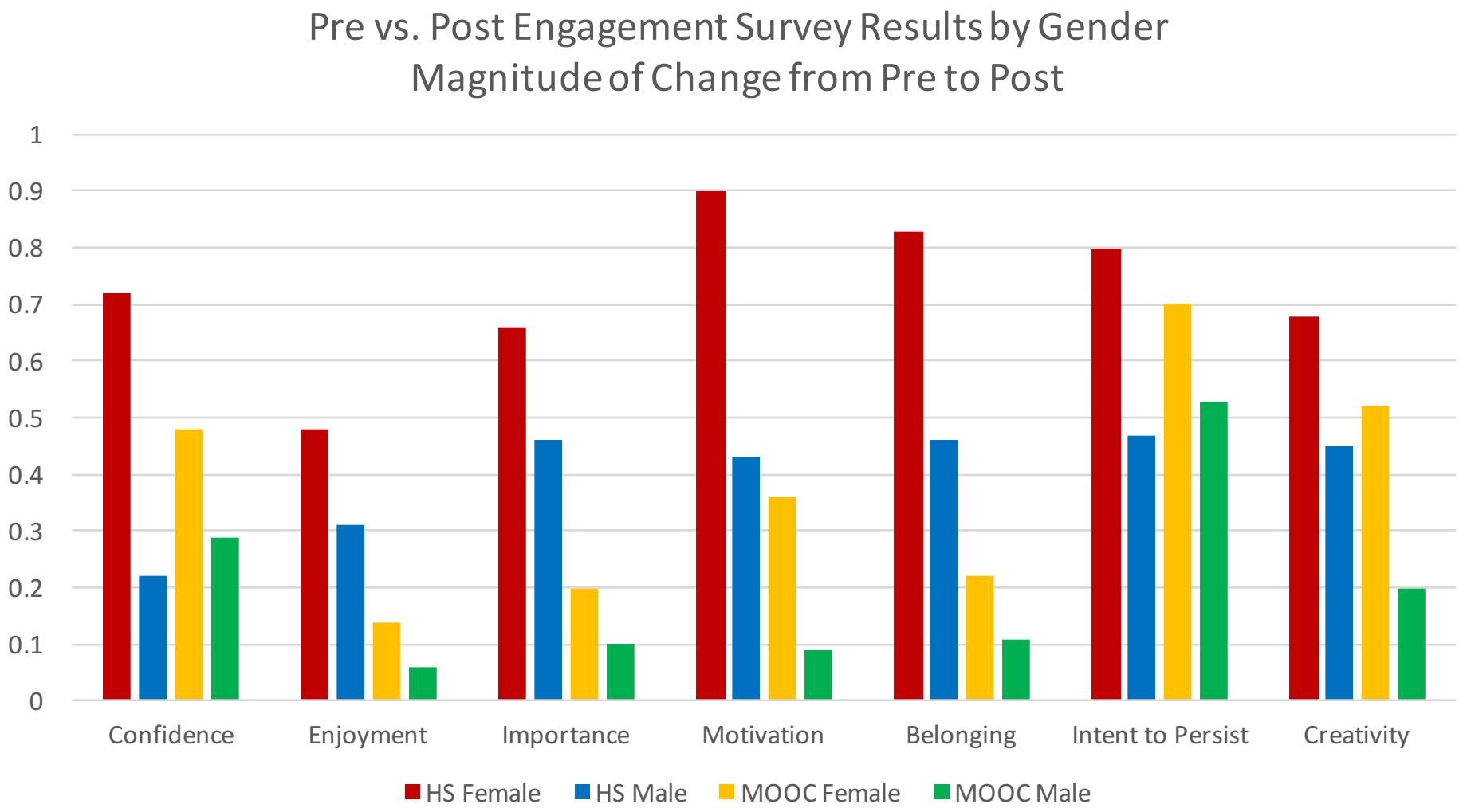
0.4
0.3
0.2
0.1
0
Confidence
Enjoyment
Importance
Motivation
Belonging
Intent to Persist
Creativity
MOOC Female
MOOC Male

COMPARISON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0.4
0.3
0.2
0.1
0
Confidence
Enjoyment
Importance
Motivation
Belonging
Intent to Persist
Creativity
HS Female
HS Male
MOOC Female
MOOC Male

NEXT STEPS FOR EARSKETCH

LEARNING ENVIRONMENT

Georgia Tech

- Blocks-based coding option (younger students)
- P5/Processing integration (audiovisual)
- Live coding
- Tabletop version (for museums)
- Tablet version
- Integration with physical computing
- Collaboration and sharing features

CURRICULUM

- Alignment with AP CS Principles
- Example-driven self-study tutorials
- University-level curriculum
- Summer-camp model
- Scalable teacher training and support

RESEARCH

- Updated creativity survey
- Updated content knowledge assessment
- Student project rubric
- Studies with control groups
- Agent-based modeling

WWW.JASONFREEMAN.NET
EARSKETCH.GATECH.EDU
WWW.GTCMT.GATECH.EDU

Project Leadership:

Jason Freeman, Brian Magerko, Douglas Edwards, Roxanne Moore, Tom McKlin

Support:

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