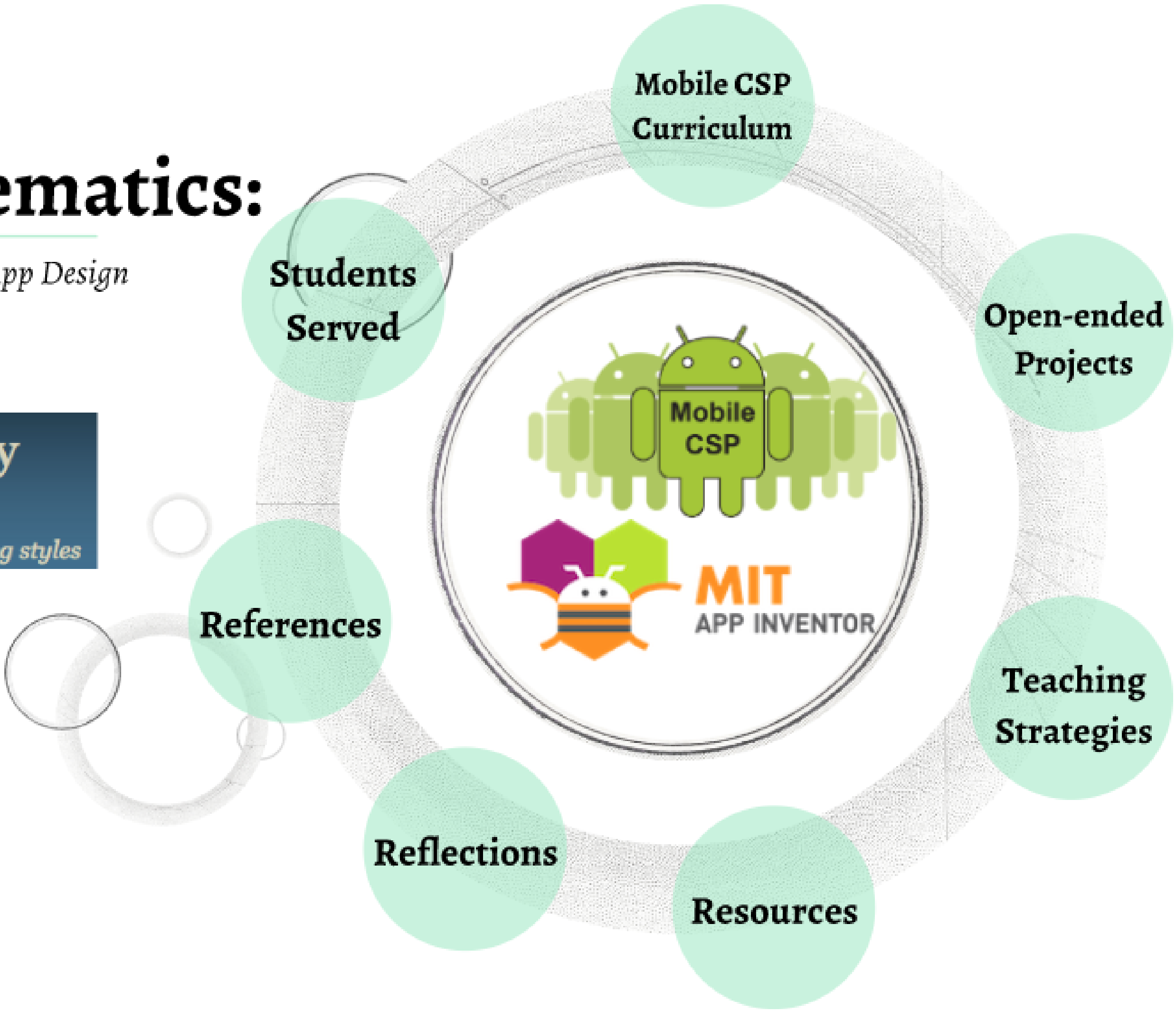
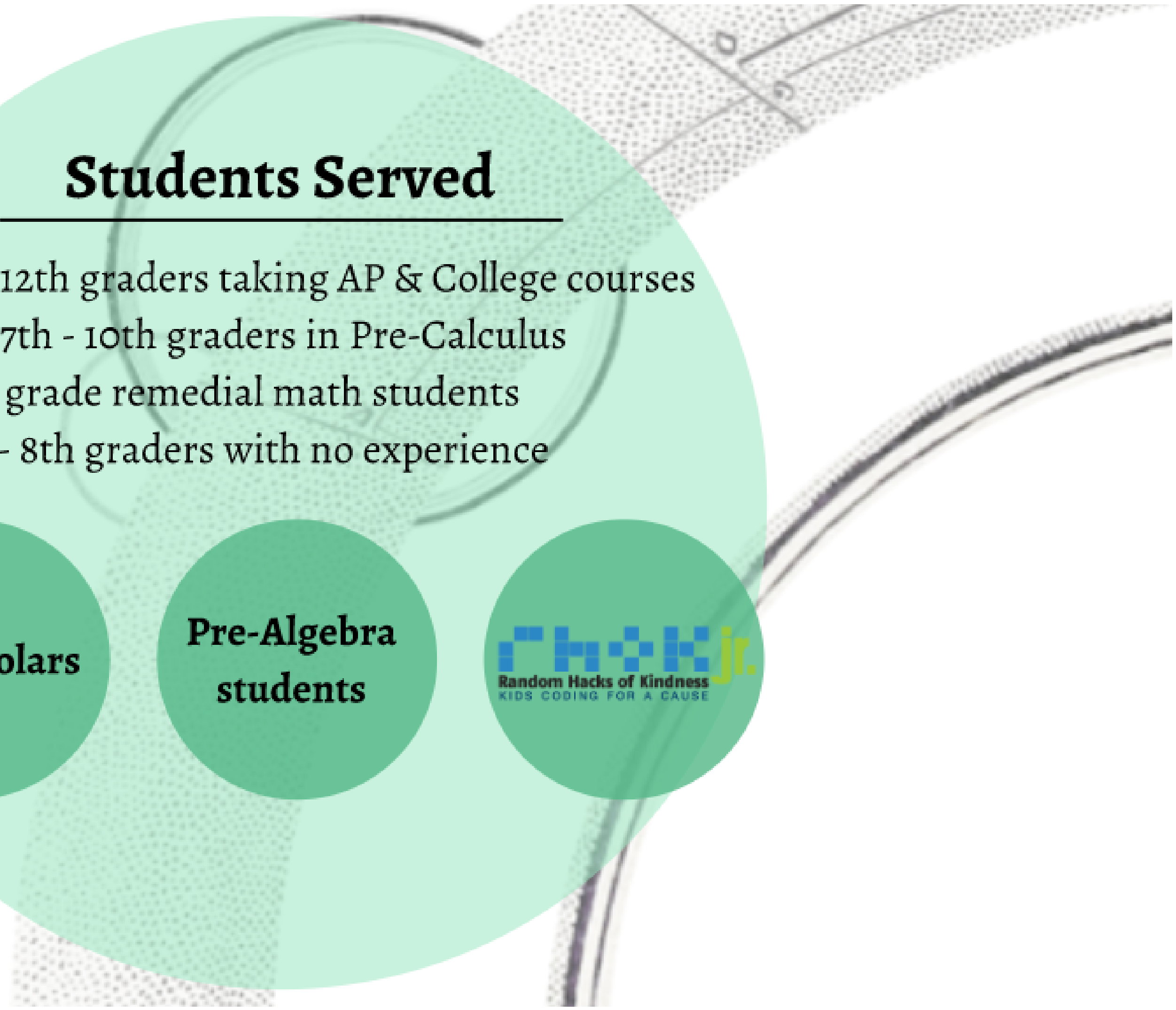
APPlied Mathematics:

The Logic, Algebra, and Geometry of App Design

Franklin Academy
BELONG | GROW | SUCCEED
Educating bright students with unique learning styles

Amy Bigelow
Math Department Chair
East Haddam, CT
fa-ct.org





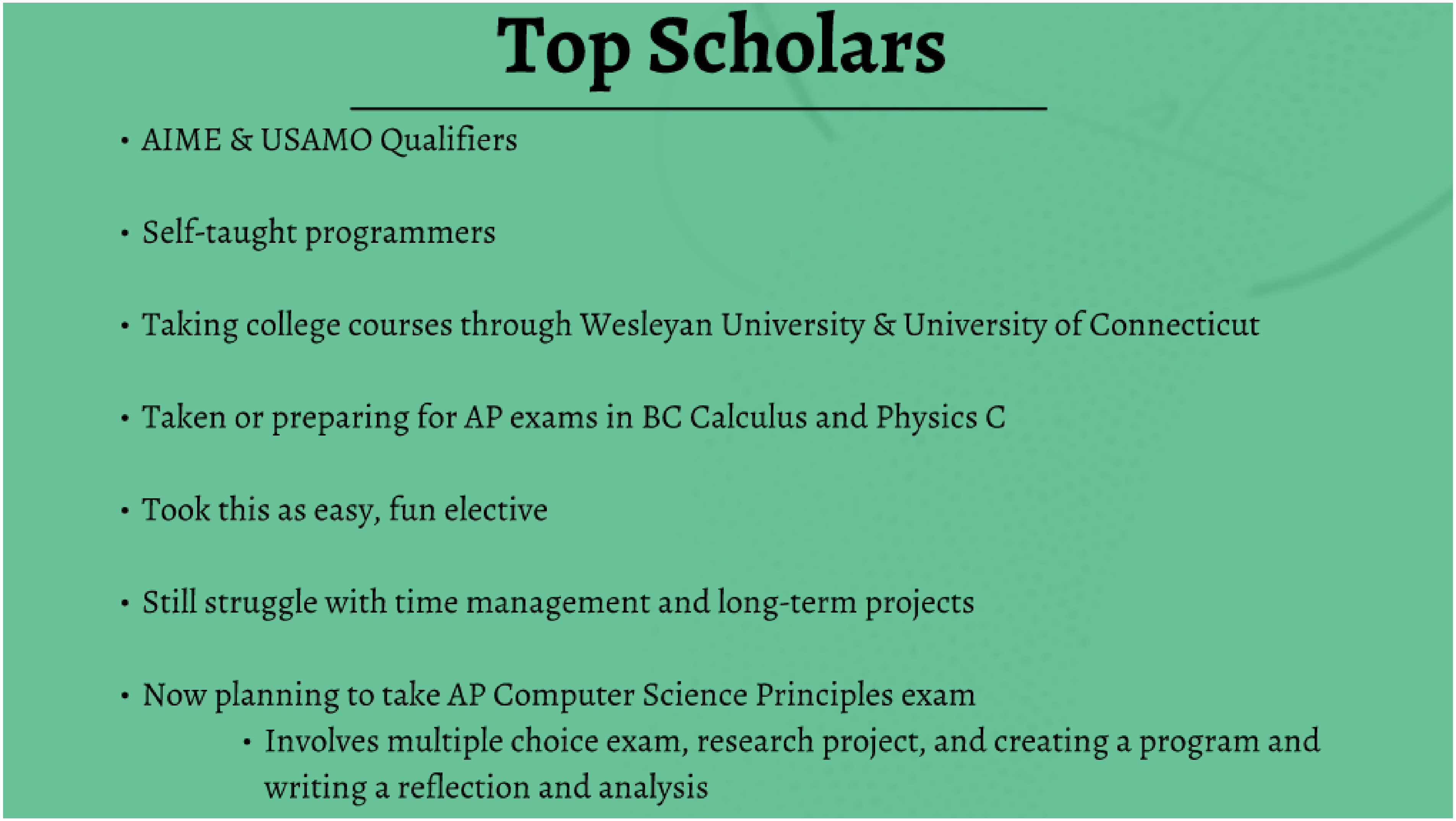
Students Served

- Top 12th graders taking AP & College courses
- Top 7th - 10th graders in Pre-Calculus
- 12th grade remedial math students
- 4th - 8th graders with no experience

Top scholars

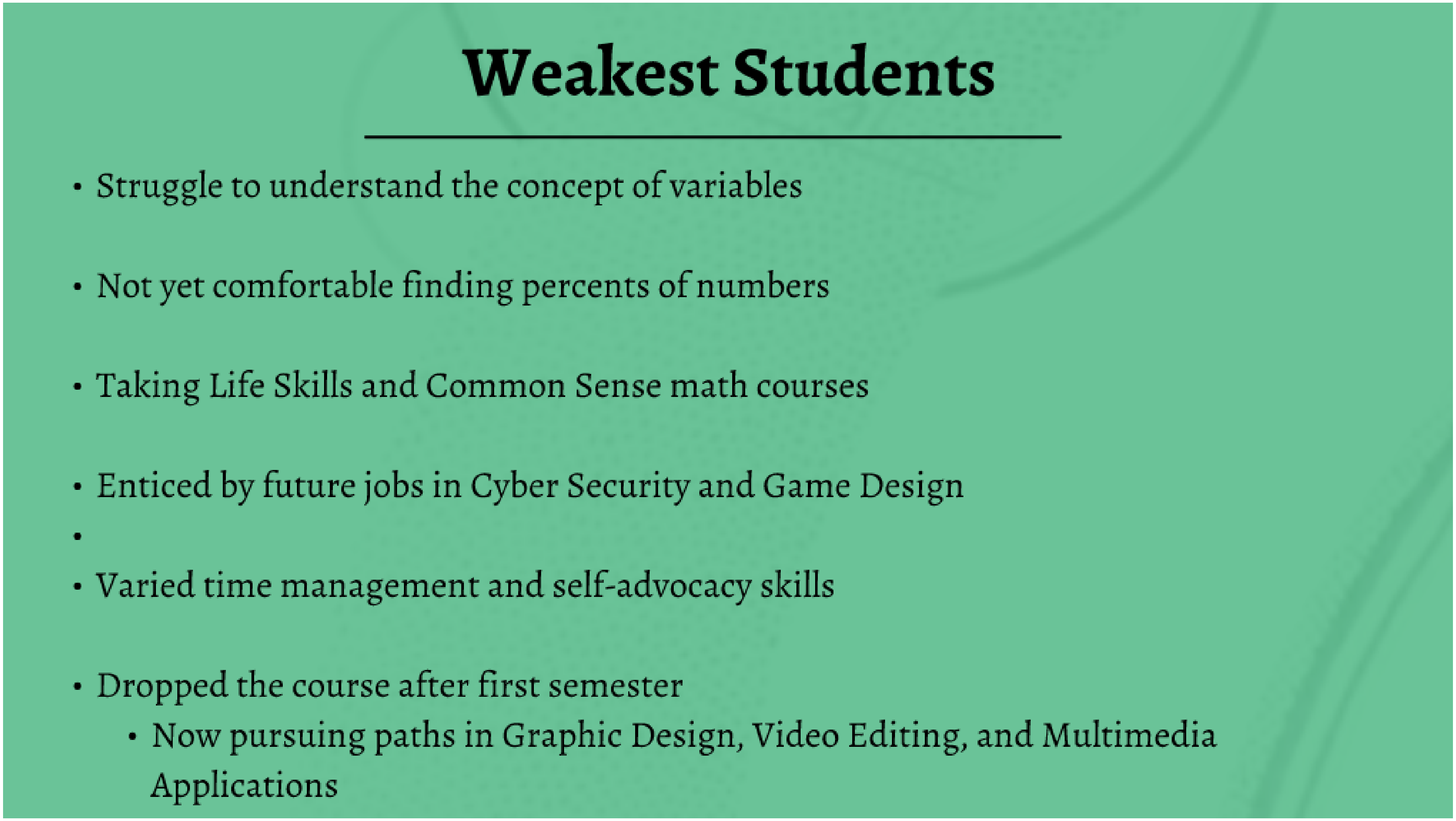
Pre-Algebra students

rhok jr.
Random Hacks of Kindness
KIDS CODING FOR A CAUSE



Top Scholars

- AIME & USAMO Qualifiers
- Self-taught programmers
- Taking college courses through Wesleyan University & University of Connecticut
- Taken or preparing for AP exams in BC Calculus and Physics C
- Took this as easy, fun elective
- Still struggle with time management and long-term projects
- Now planning to take AP Computer Science Principles exam
    - Involves multiple choice exam, research project, and creating a program and writing a reflection and analysis



Weakest Students

- Struggle to understand the concept of variables
- Not yet comfortable finding percents of numbers
- Taking Life Skills and Common Sense math courses
- Enticed by future jobs in Cyber Security and Game Design
-
- Varied time management and self-advocacy skills
- Dropped the course after first semester
  - Now pursuing paths in Graphic Design, Video Editing, and Multimedia Applications

Random Hacks of Kindness jr.

KIDS CODING FOR A CAUSE

- One-day hackathons
- 4th - 8th graders with no prior experience
- Design an app that supports a non-profit's mission

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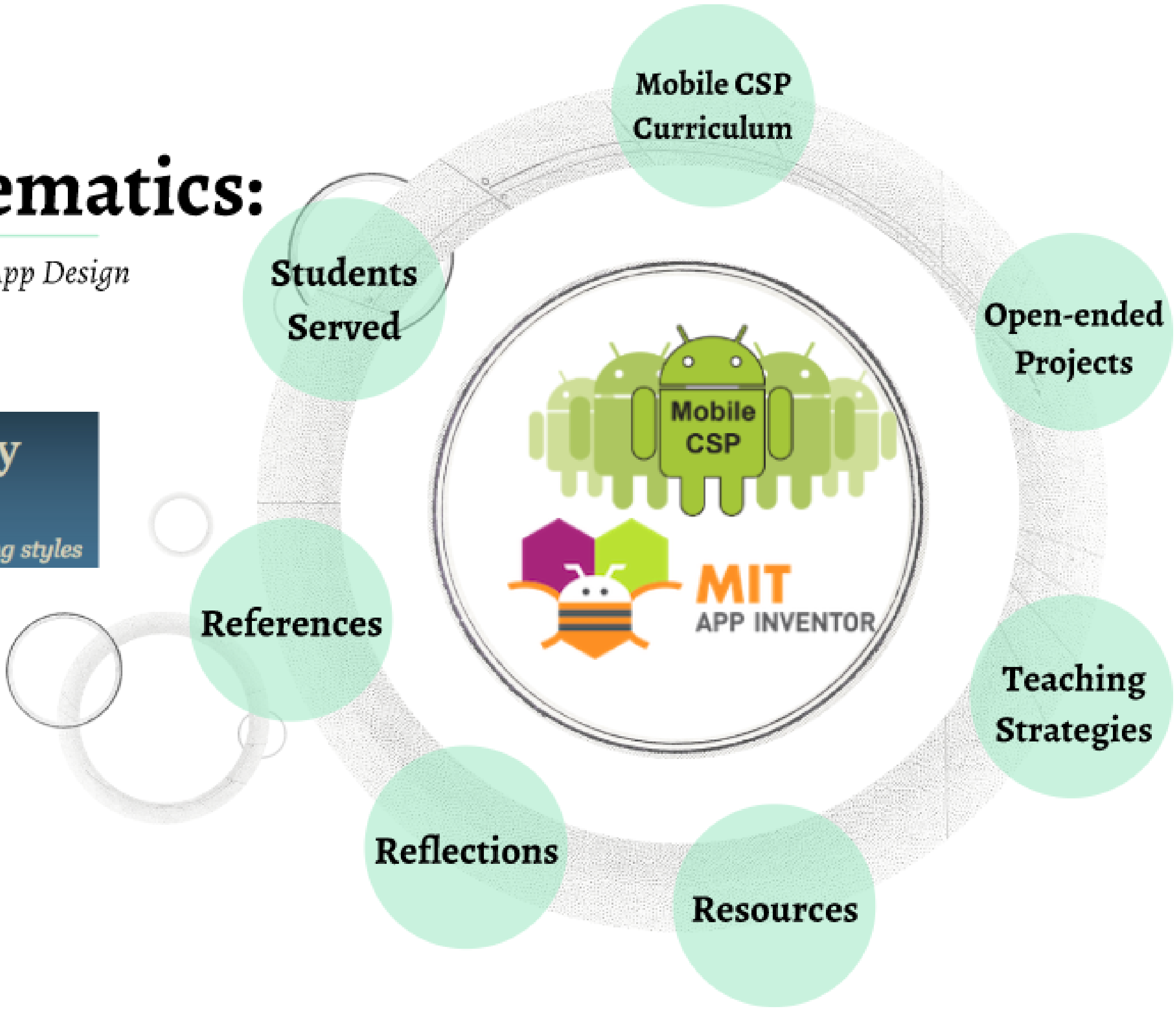


Mobile CSP Curriculum

Open-ended Projects

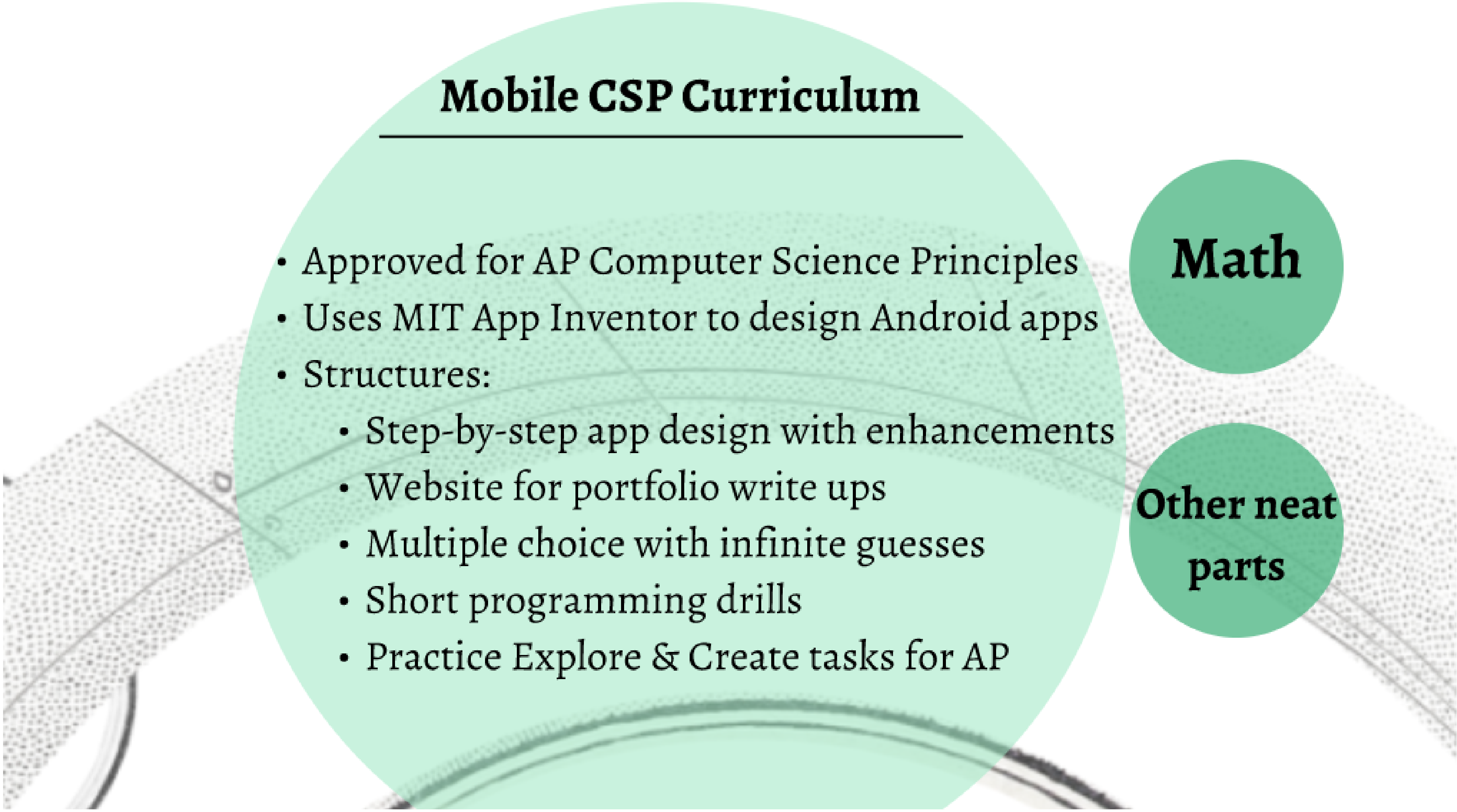
Teaching Strategies

Resources

Reflections

References

Students Served

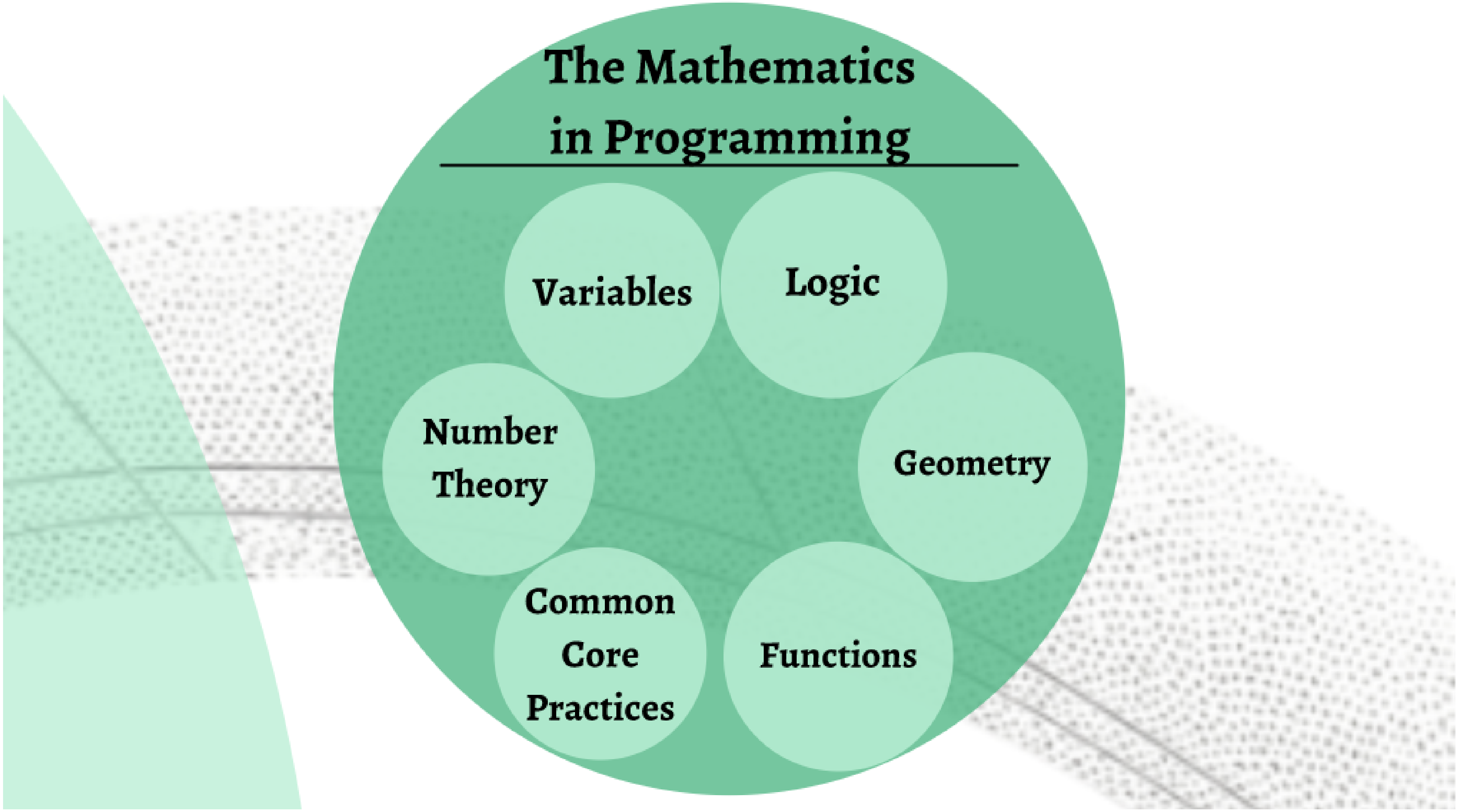


Mobile CSP Curriculum

- Approved for AP Computer Science Principles
- Uses MIT App Inventor to design Android apps
- Structures:
  - Step-by-step app design with enhancements
  - Website for portfolio write ups
  - Multiple choice with infinite guesses
  - Short programming drills
  - Practice Explore & Create tasks for AP

Math

Other neat parts



The Mathematics in Programming

Variables

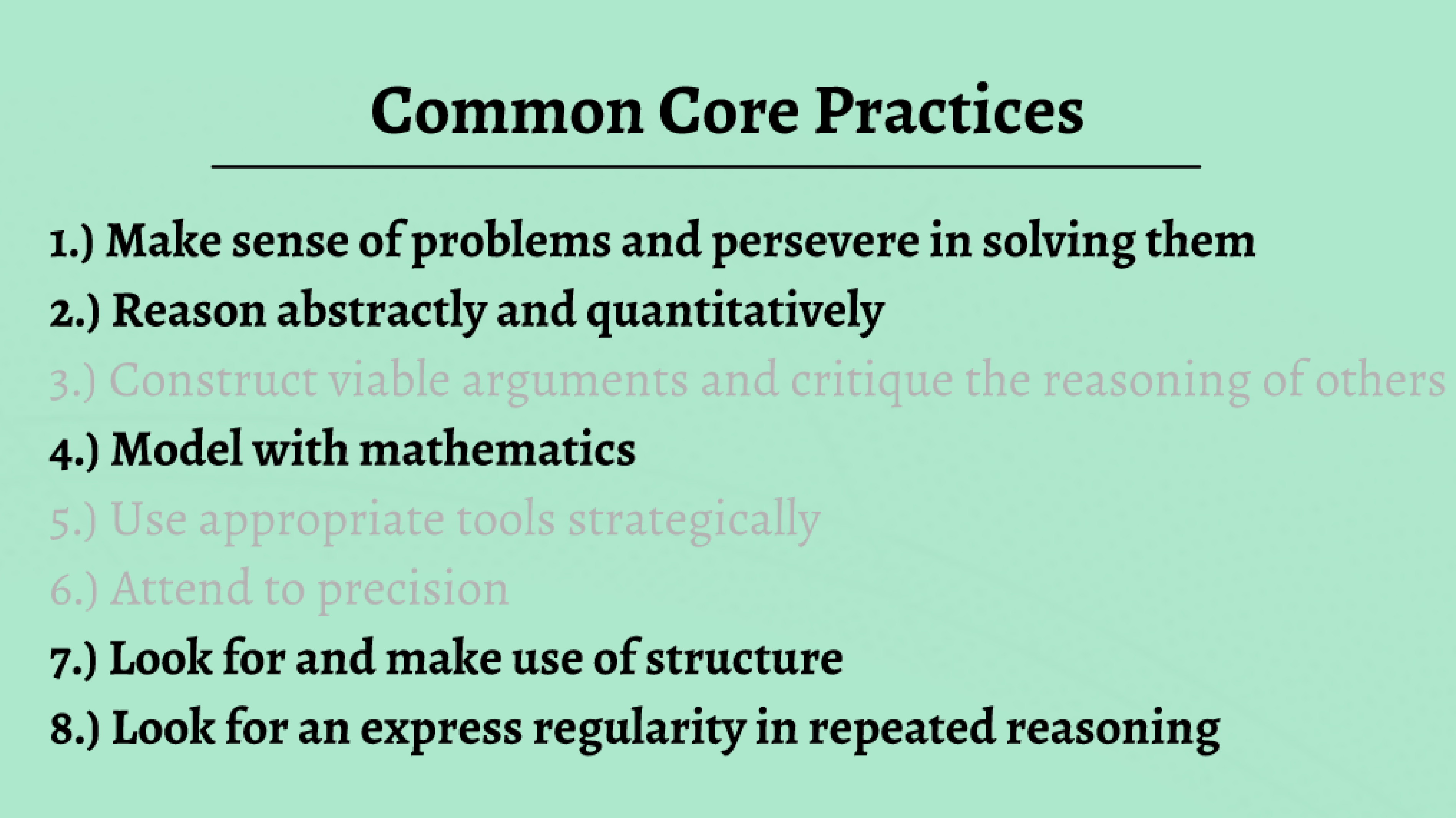
Logic

Number Theory

Geometry

Common Core Practices

Functions



Common Core Practices

1.) **Make sense of problems and persevere in solving them**

2.) **Reason abstractly and quantitatively**

3.) Construct viable arguments and critique the reasoning of others

4.) **Model with mathematics**

5.) Use appropriate tools strategically

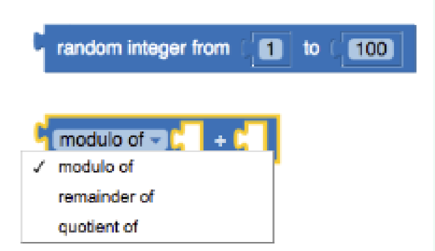
6.) Attend to precision

7.) **Look for and make use of structure**

8.) **Look for an express regularity in repeated reasoning**

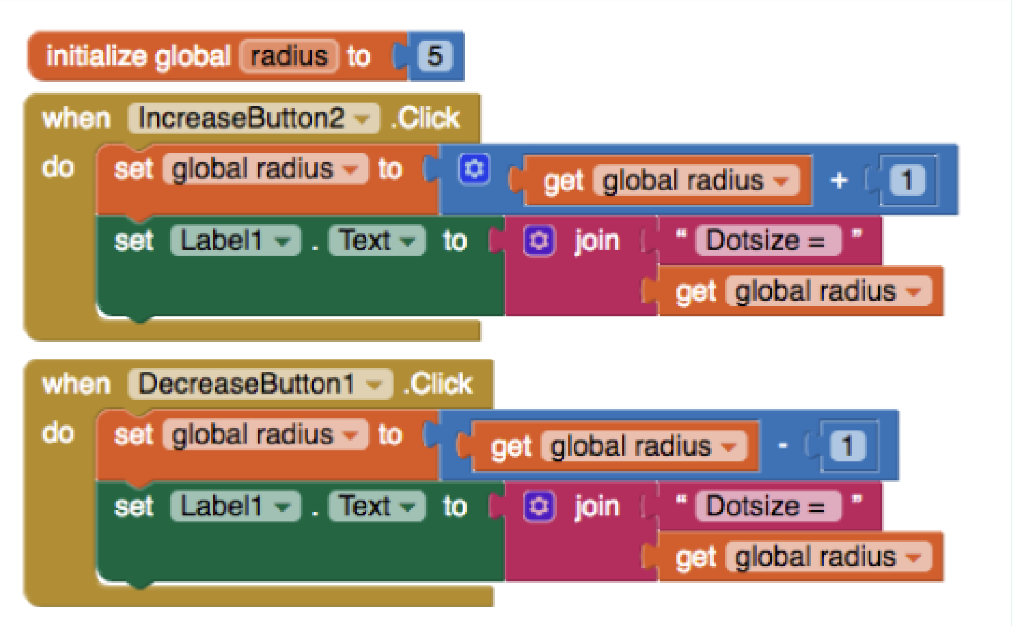
Number Theory

- Using different bases (binary, hexadecimal)
  - With unit conversion (1 byte = 8 bits)
  - Basic combinatorics (How many values can this system encode?)
  - Exponents and very large numbers



- Modular arithmetic
  - mod 2 for error detection (parity arguments)
  - Pseudo-random number generators (recursion: $x_{n+1} = (2x_n + 1) \bmod 13$)
  - RSA encryption: m^kmodN, factoring, and relatively prime numbers

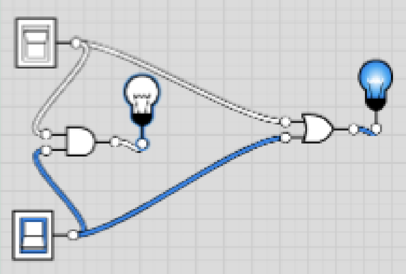
Variables



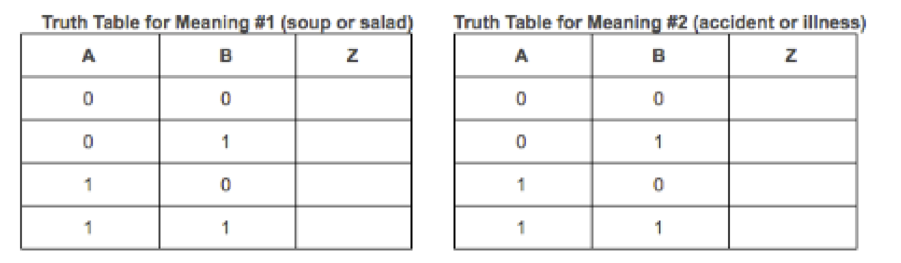
```
initialize global radius to 5

when IncreaseButton2 .Click
do  set global radius to   get global radius + 1
    set Label1 . Text to   join  " Dotsize = "
                                 get global radius

when DecreaseButton1 .Click
do  set global radius to   get global radius - 1
    set Label1 . Text to   join  " Dotsize = "
                                 get global radius
```

Logic

- As physical gates and wiring diagrams
  - Simulated in logic.ly



- Abstracted to truth tables
  - with differences in English



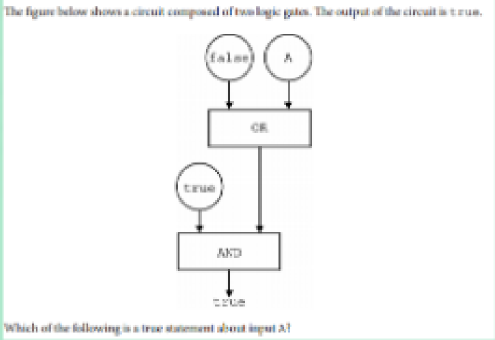
Truth Table for Meaning #1 (soup or salad)

A	B	Z
0	0	
0	1	
1	0	
1	1	

Truth Table for Meaning #2 (accident or illness)

A	B	Z
0	0	
0	1	
1	0	
1	1	

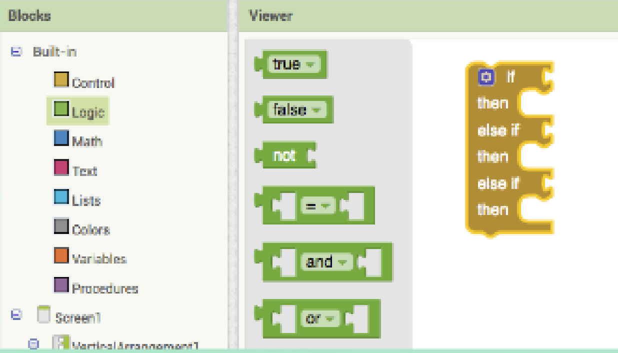
- In flow charts as program outlines



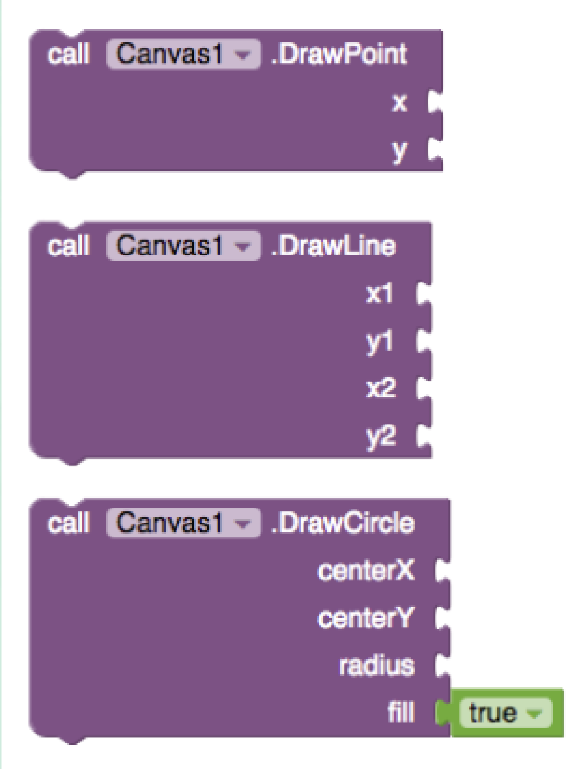
The figure below shows a circuit composed of two logic gates. The output of the circuit is true.

Which of the following is a true statement about input A?

- As parts of useable code



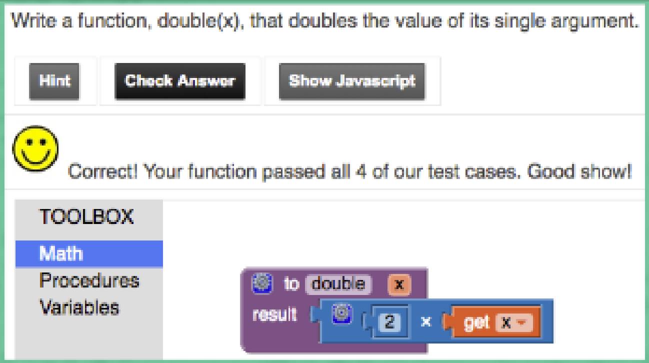
Geometry



```
call Canvas1 .DrawPoint
                      x
                      y

call Canvas1 .DrawLine
                     x1
                     y1
                     x2
                     y2

call Canvas1 .DrawCircle
                   centerX
                   centerY
                    radius
                      fill  true
```

- Determining necessary rotations to produce regular n-gons

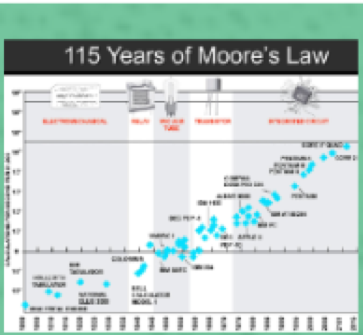
Functions



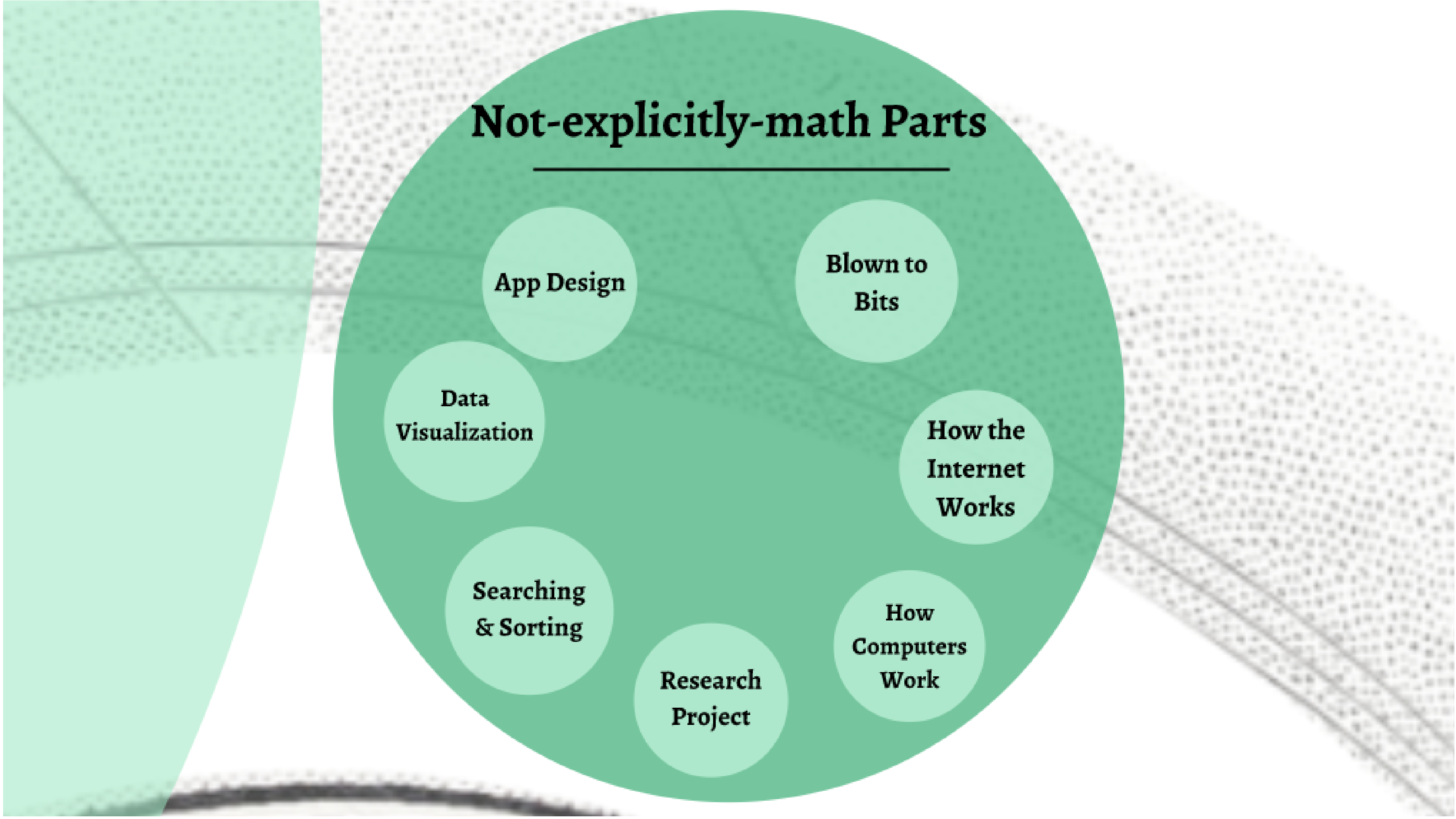
Write a function, double(x), that doubles the value of its single argument.

Correct! Your function passed all 4 of our test cases. Good show!

- Moore's Law (exponential growth)



- Comparing run-time of sorting and searching algorithms (logarithmic, linear, quadratic, exponential, factorial)
- Simple substitution ciphers (f(x)=x+a)



Not-explicitly-math Parts

App Design

Blown to Bits

Data Visualization

How the Internet Works

Searching & Sorting

How Computers Work

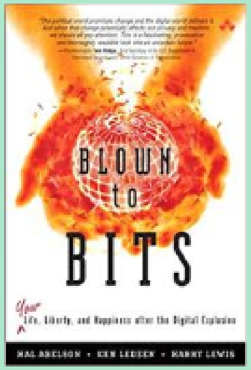
Research Project

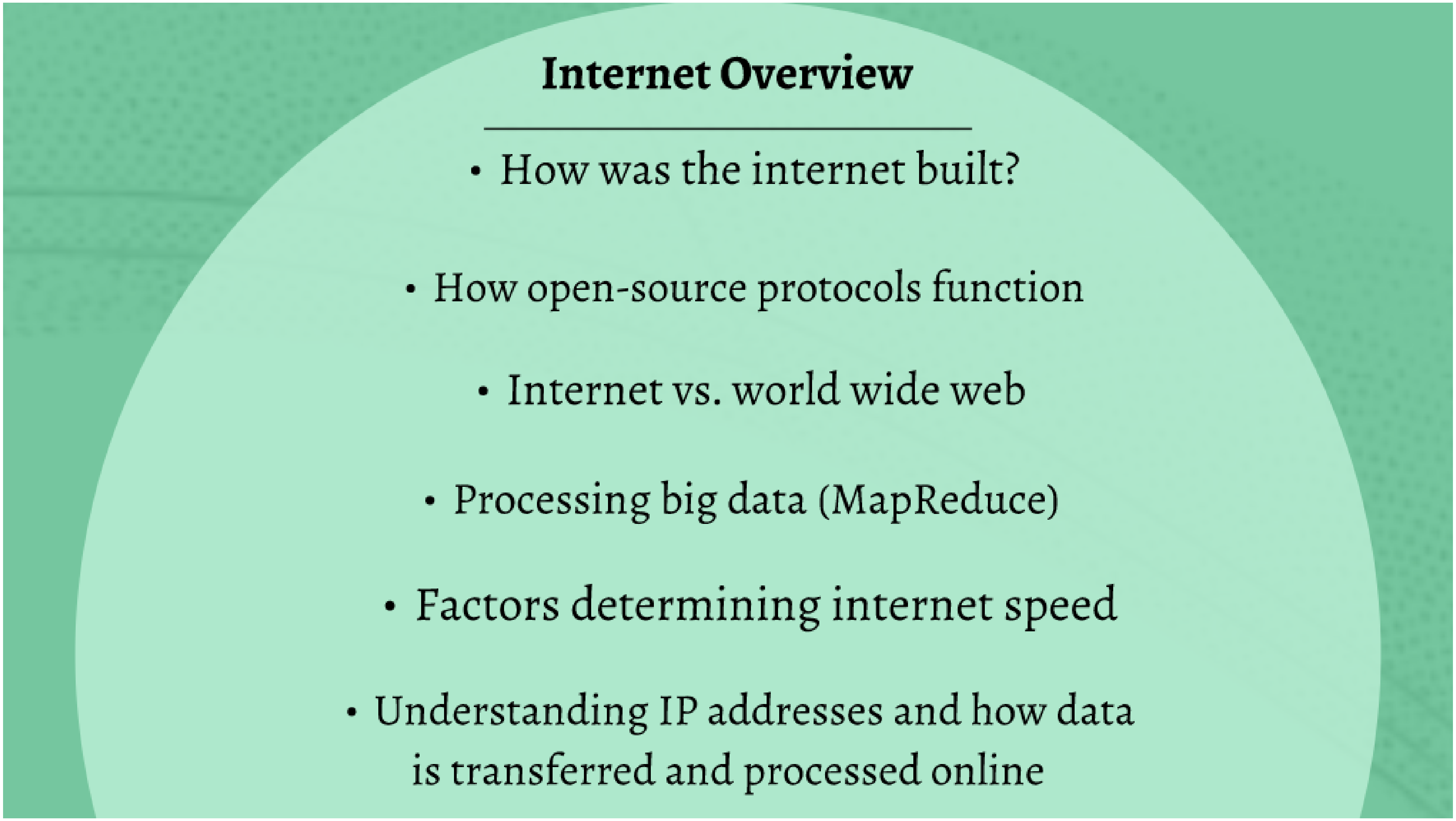
Your Life, Liberty, and Happiness after the Digital Explosion

BLOWN to BITS

HAL ABELSON • KEN LEDEEN • HARRY LEWIS

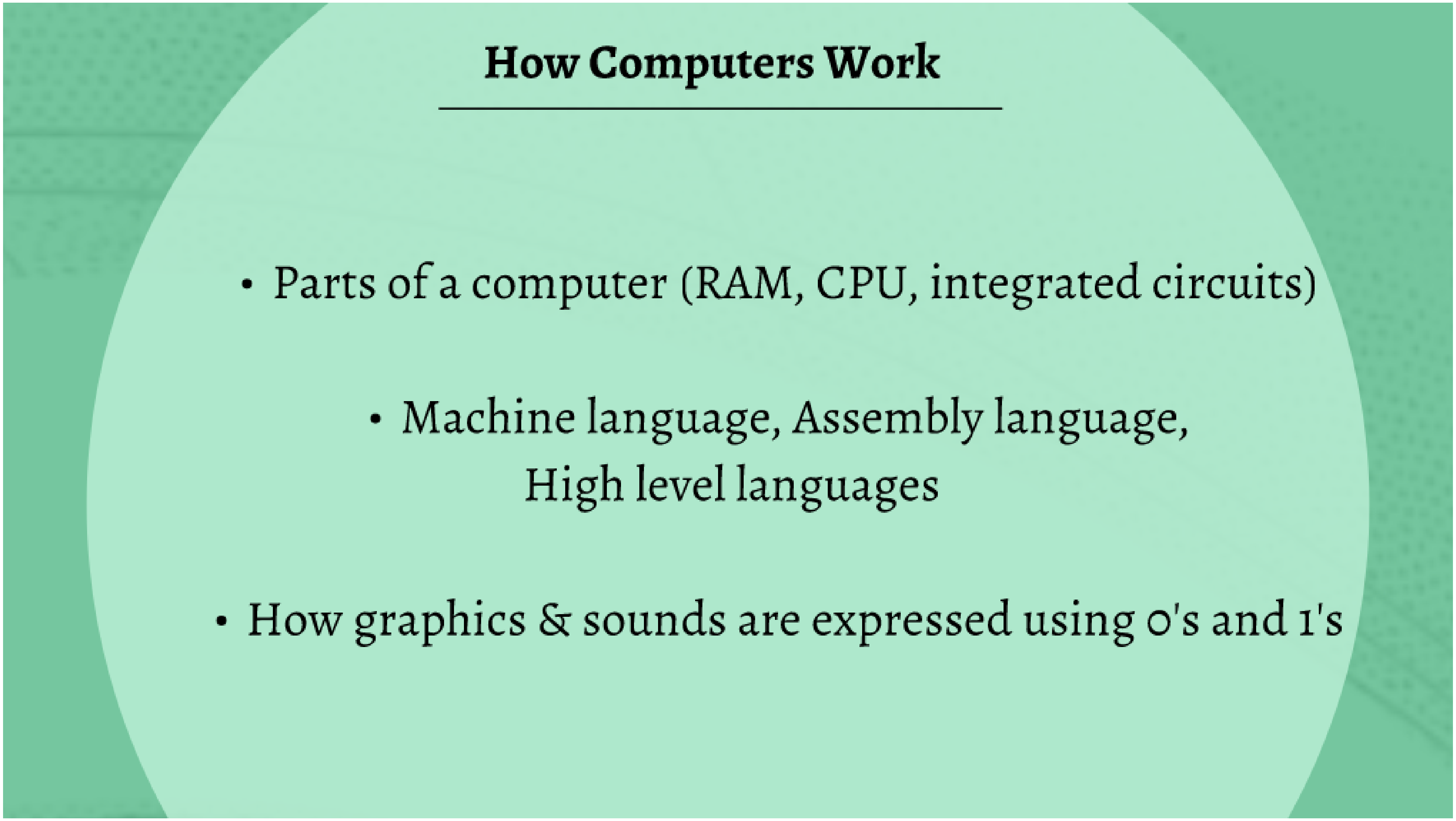
- Free as PDF
- Examines issues of privacy and security in the 21st century
- Shows development of technology and how laws and practices connect


BLOWN to BITS
Your Life, Liberty, and Happiness after the Digital Explosion
HAL ABELSON • KEN LEDEEN • HARRY LEWIS



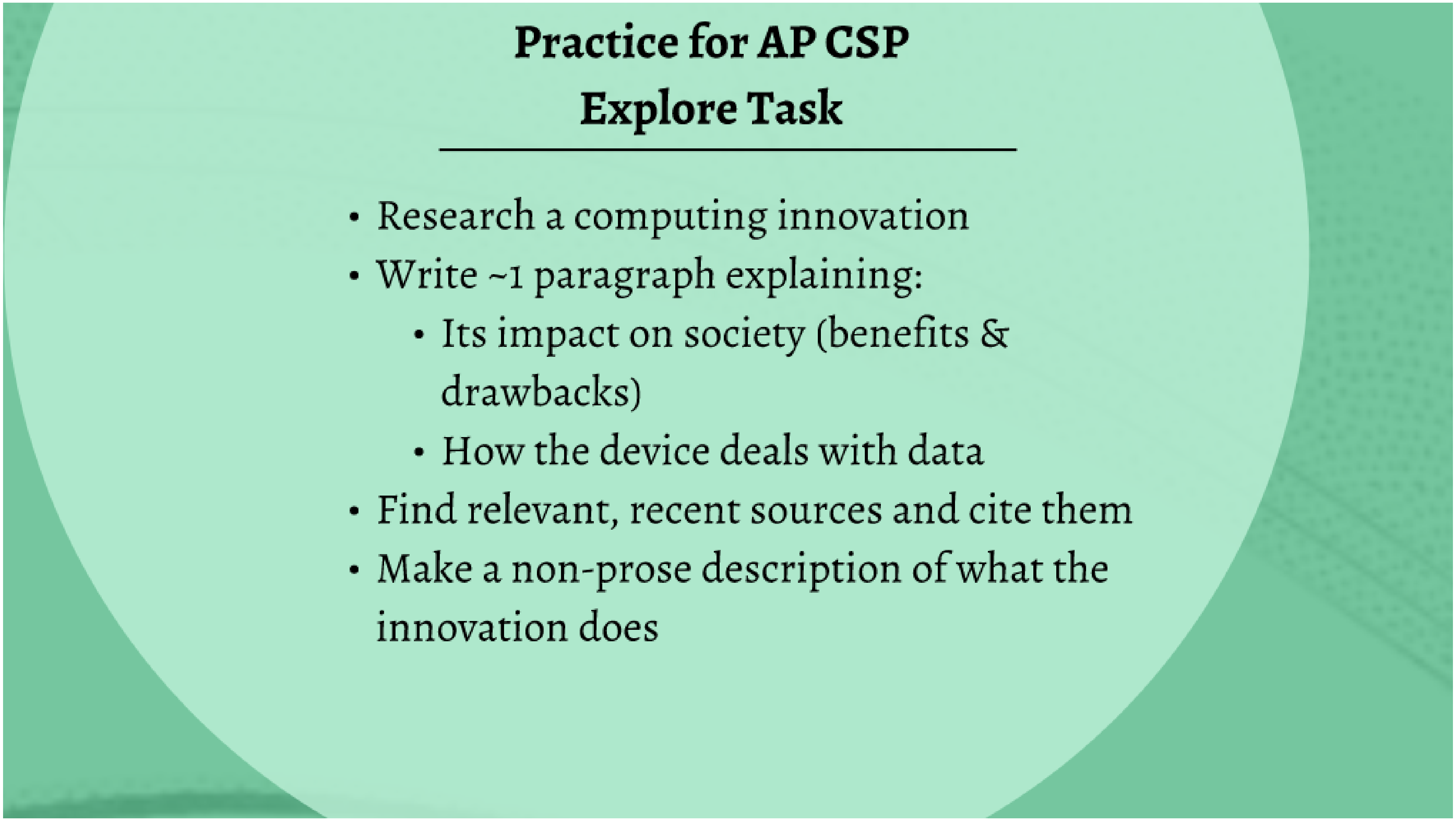
Internet Overview

- How was the internet built?
- How open-source protocols function
- Internet vs. world wide web
- Processing big data (MapReduce)
- Factors determining internet speed
- Understanding IP addresses and how data is transferred and processed online



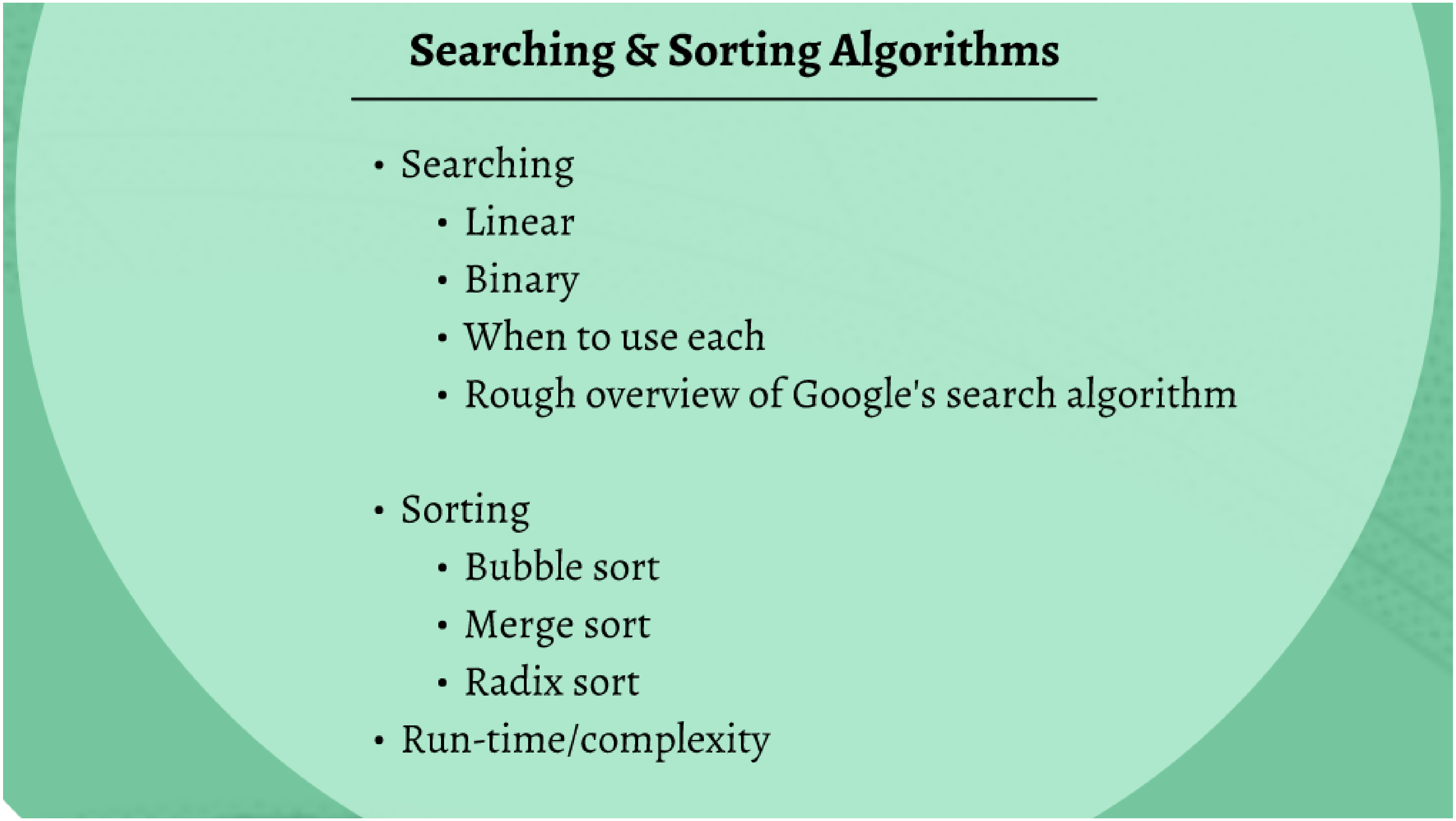
How Computers Work

- Parts of a computer (RAM, CPU, integrated circuits)
- Machine language, Assembly language,
  High level languages
- How graphics & sounds are expressed using 0's and 1's



Practice for AP CSP Explore Task

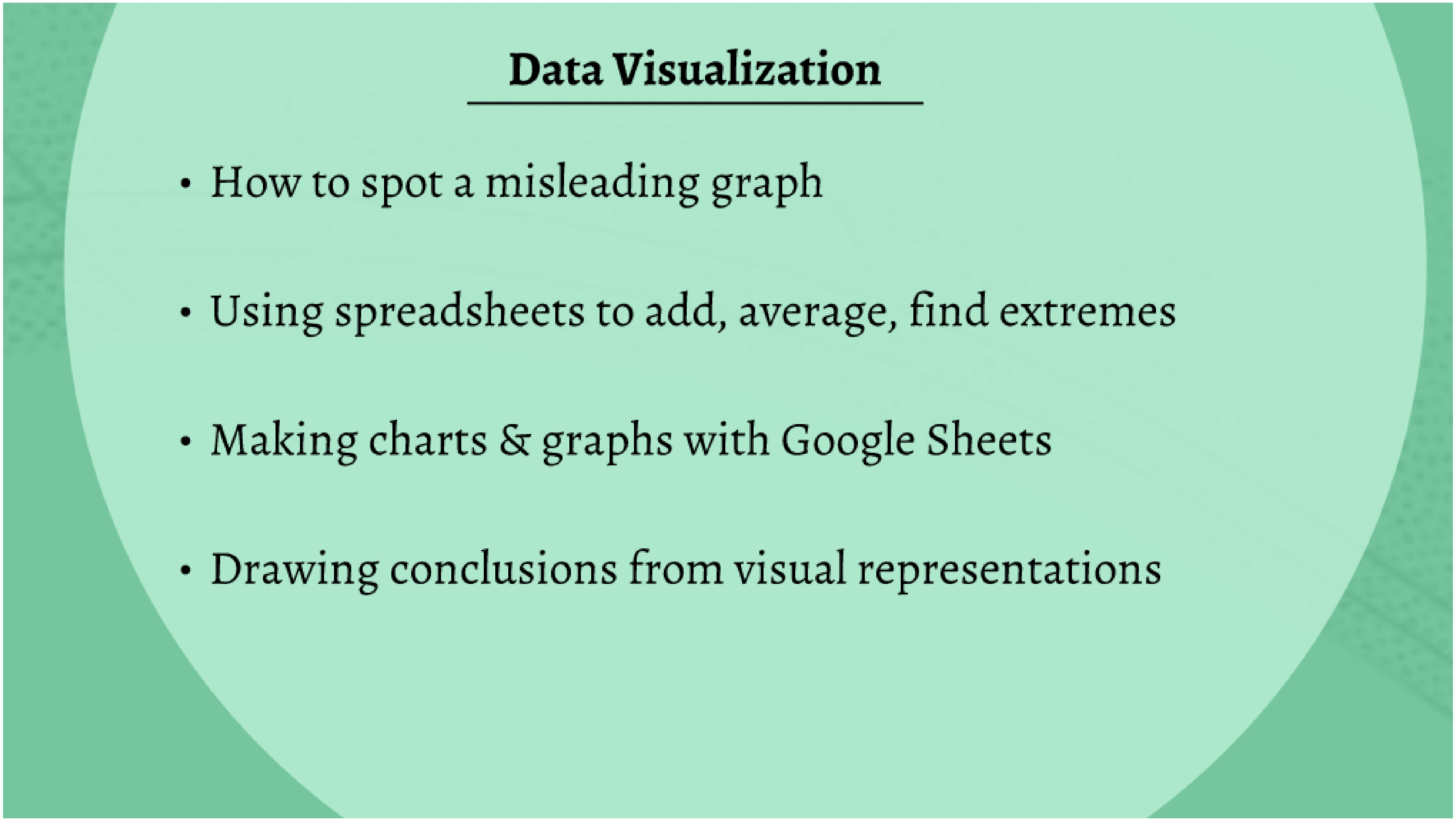
- Research a computing innovation
- Write ~1 paragraph explaining:
  - Its impact on society (benefits & drawbacks)
  - How the device deals with data
- Find relevant, recent sources and cite them
- Make a non-prose description of what the innovation does



Searching & Sorting Algorithms

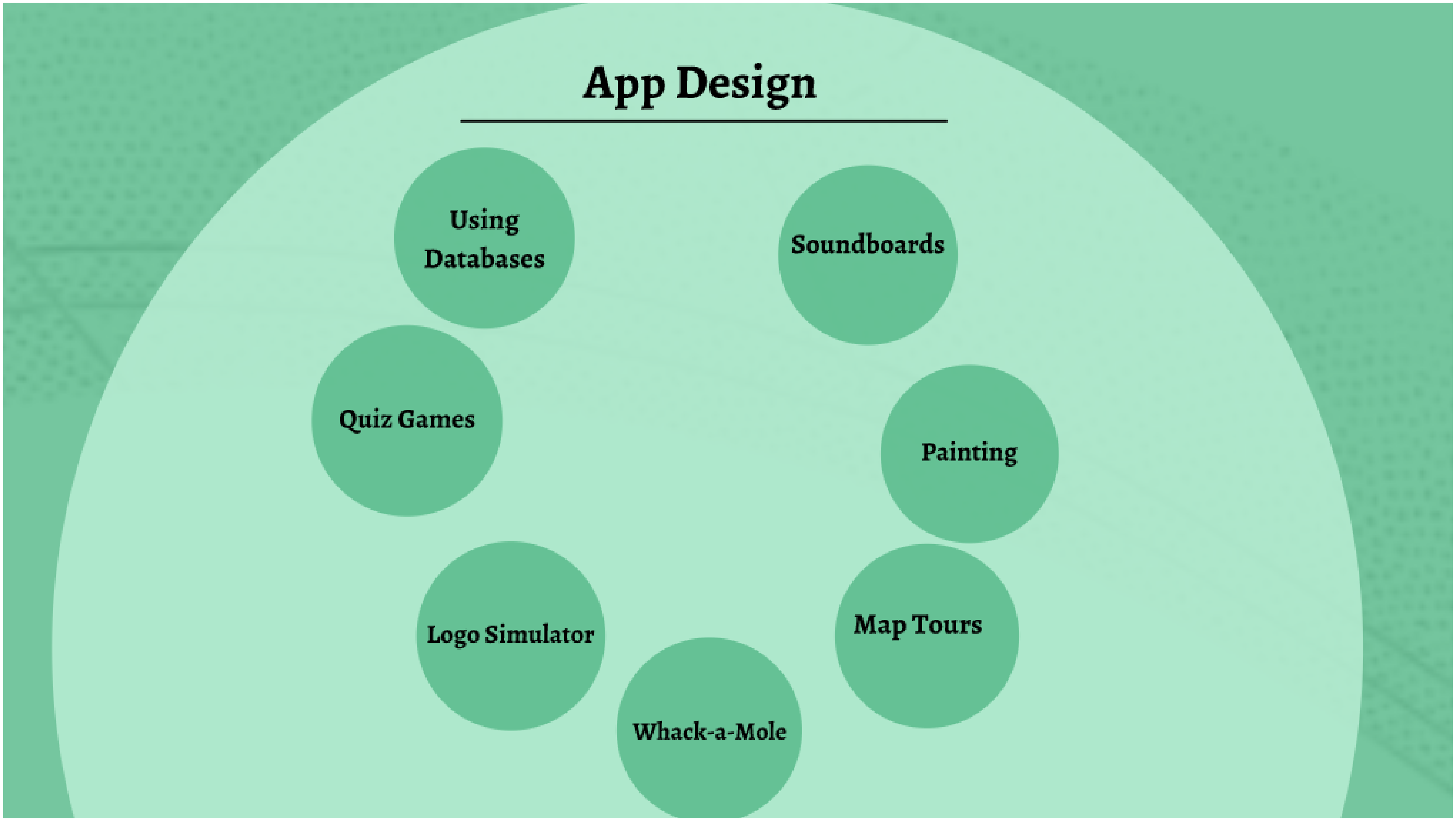
- Searching
  - Linear
  - Binary
  - When to use each
  - Rough overview of Google's search algorithm

- Sorting
  - Bubble sort
  - Merge sort
  - Radix sort
- Run-time/complexity



Data Visualization

- How to spot a misleading graph
- Using spreadsheets to add, average, find extremes
- Making charts & graphs with Google Sheets
- Drawing conclusions from visual representations



App Design

Using Databases

Soundboards

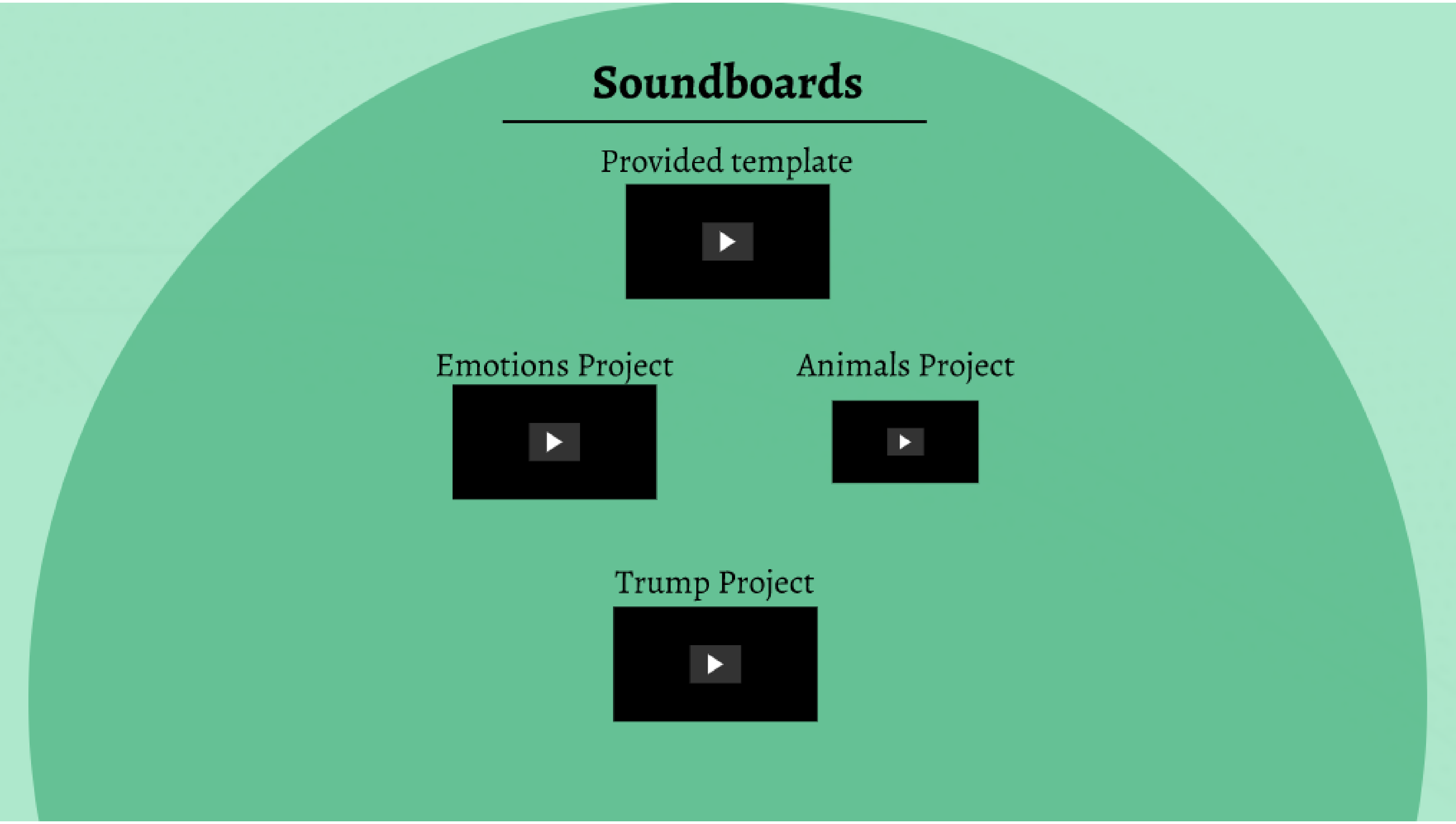
Quiz Games

Painting

Logo Simulator

Map Tours

Whack-a-Mole



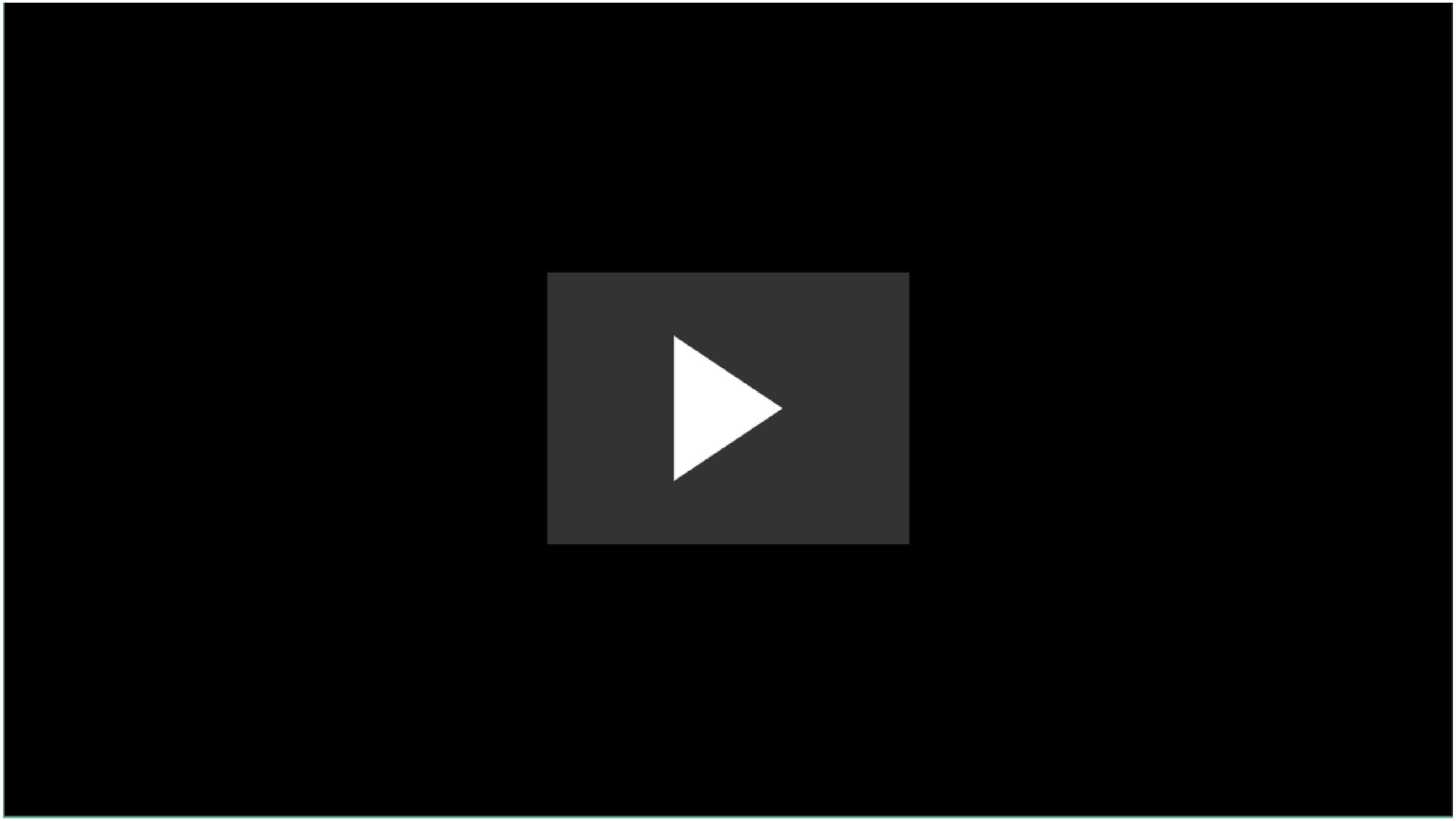
Soundboards

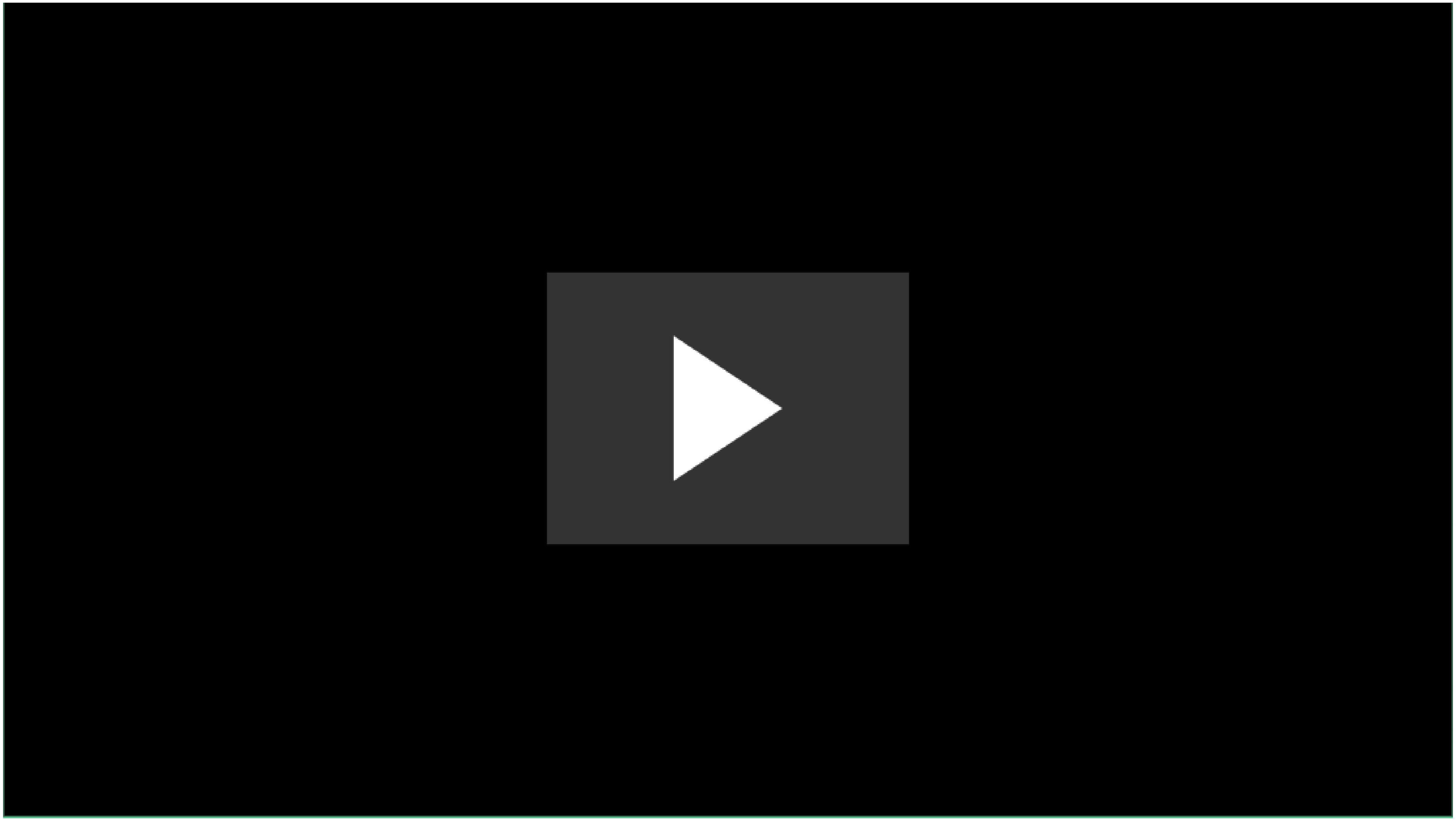
Provided template

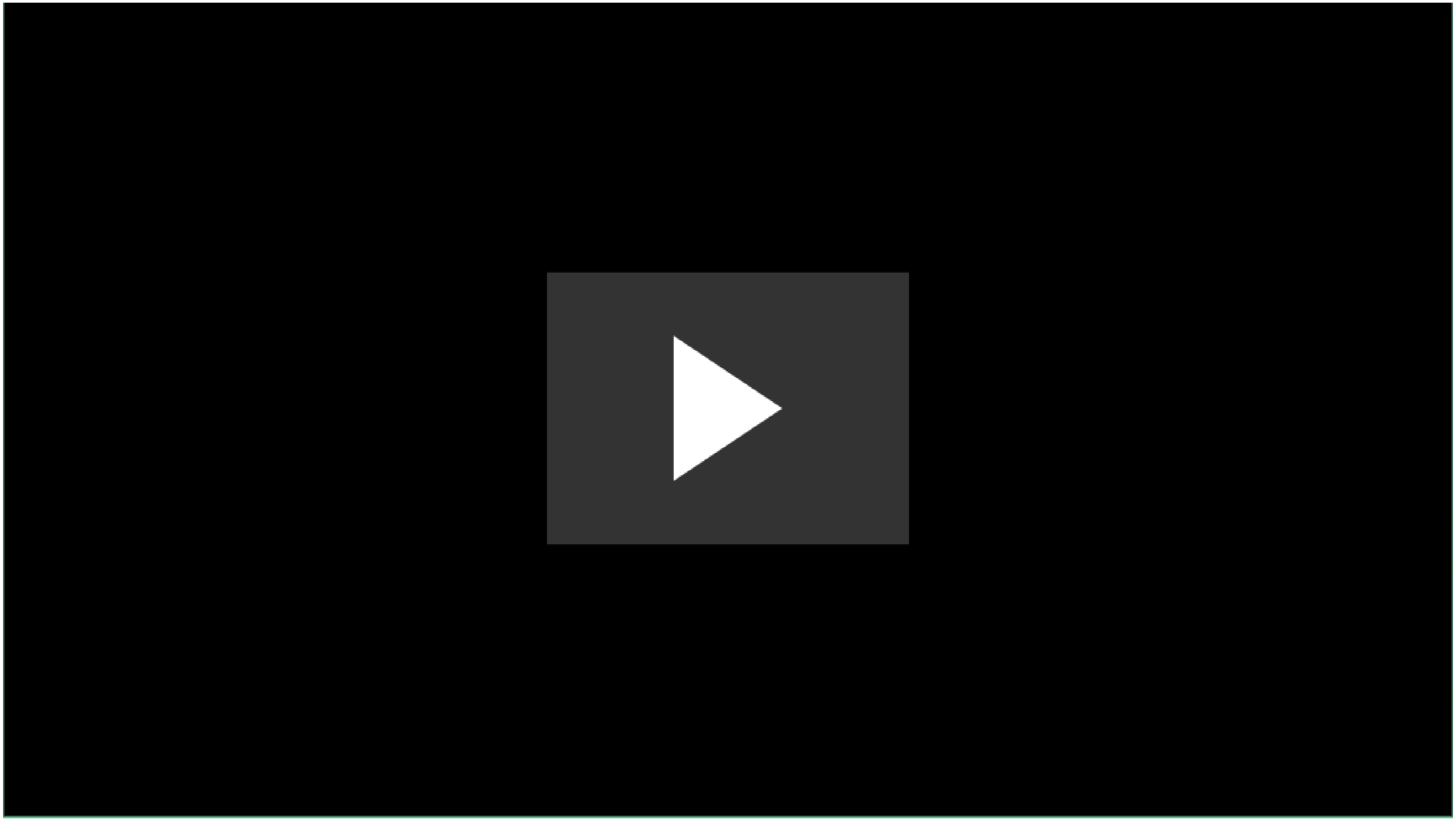
Emotions Project

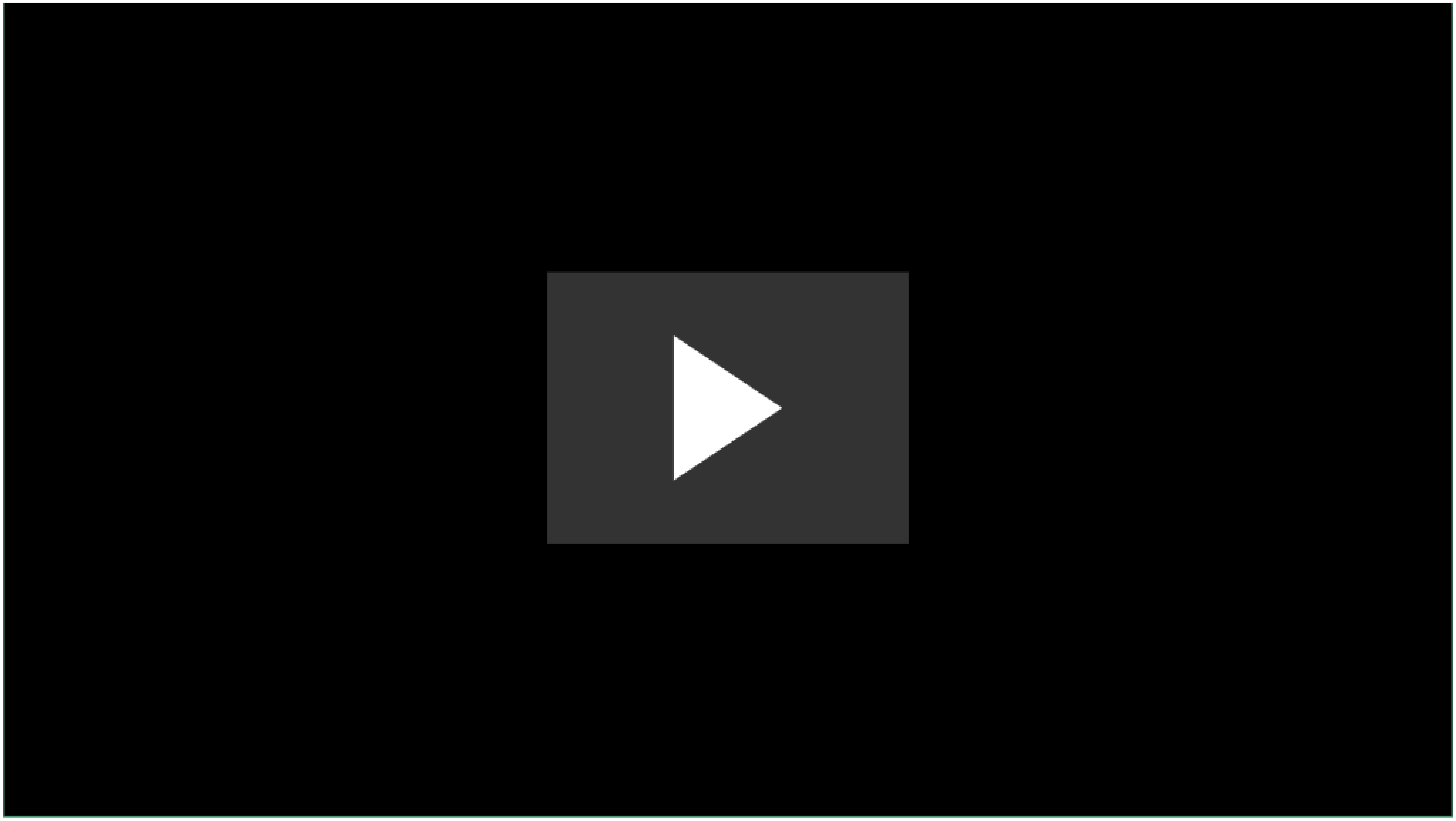
Animals Project

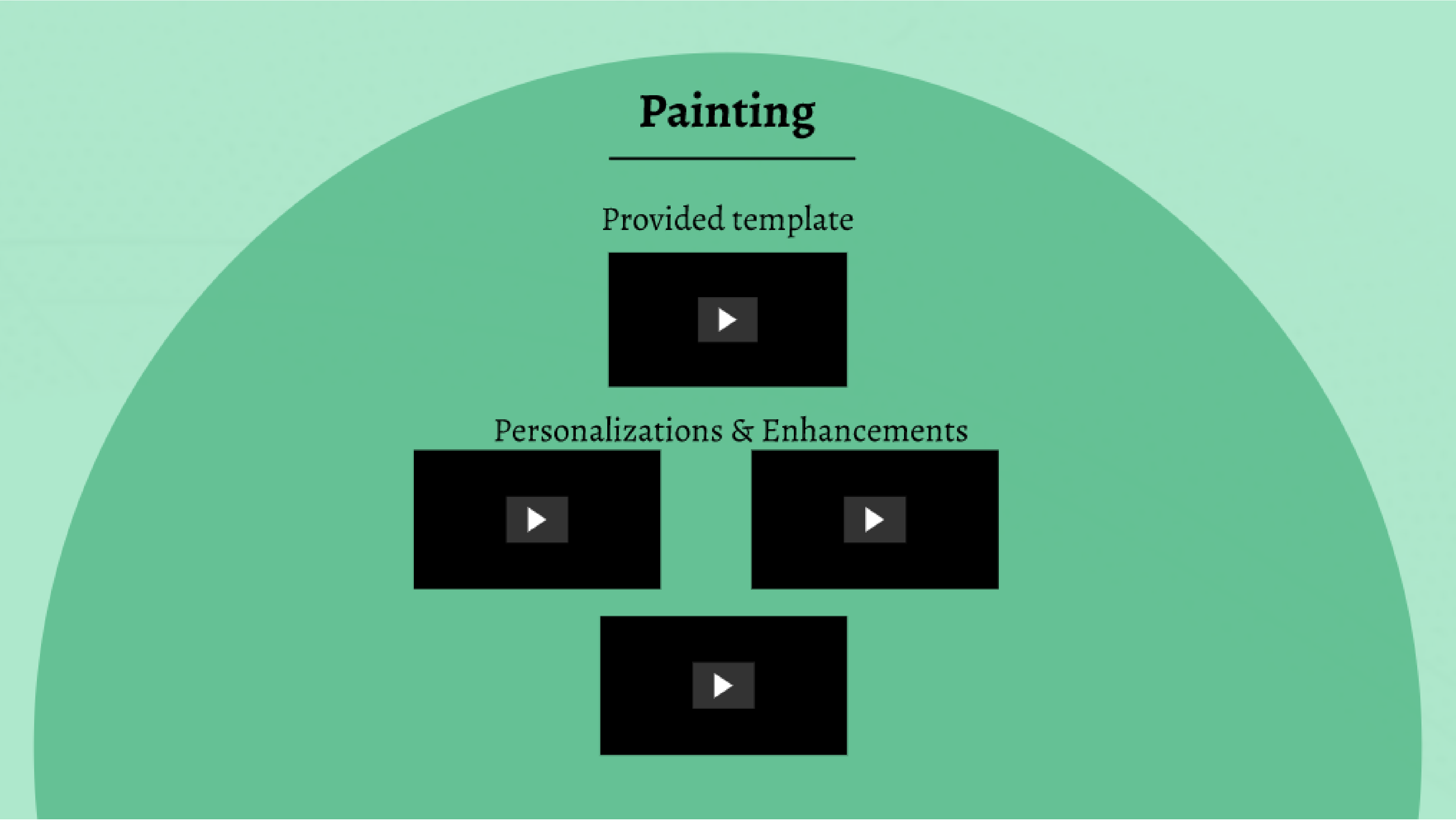
Trump Project







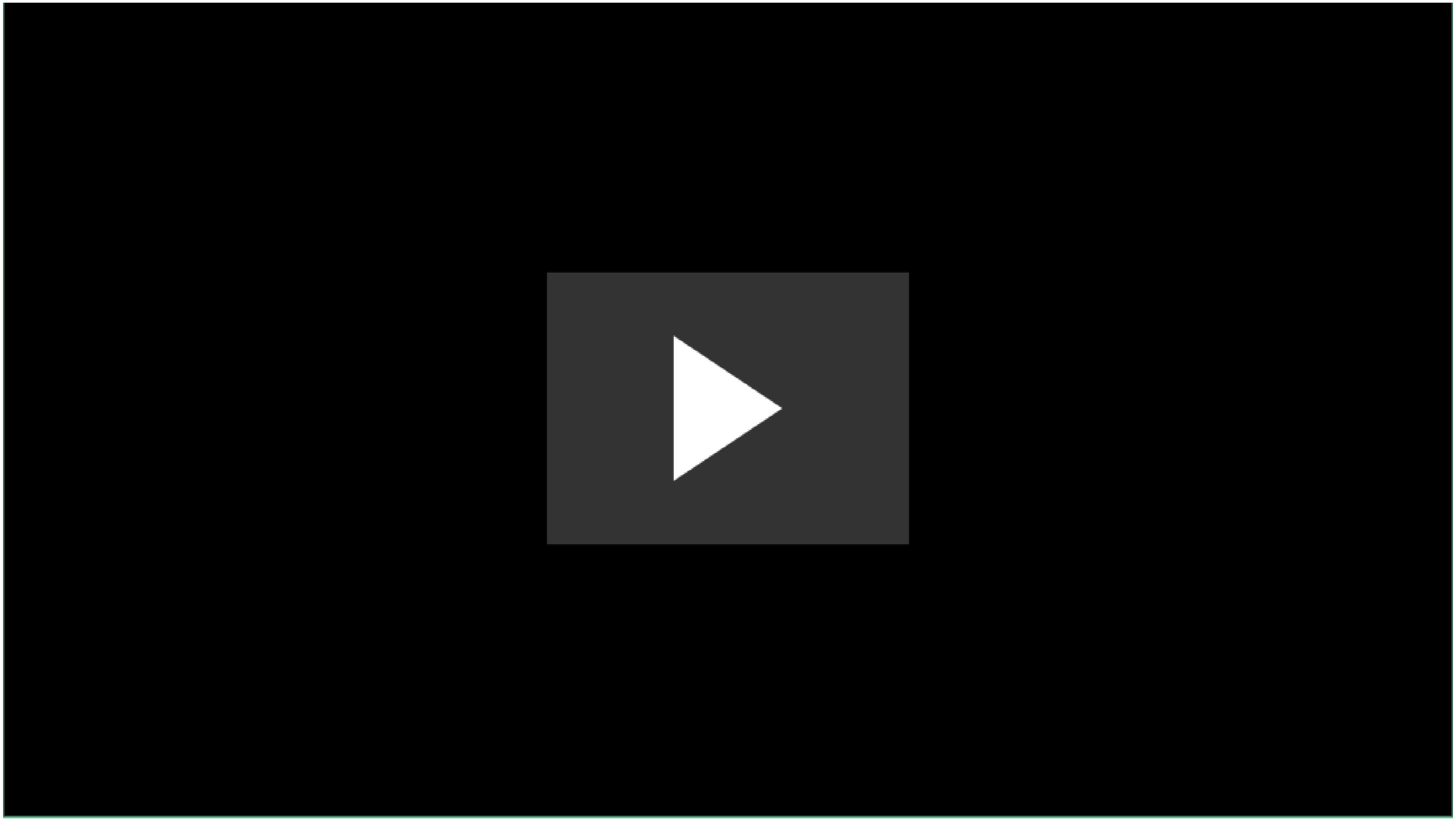


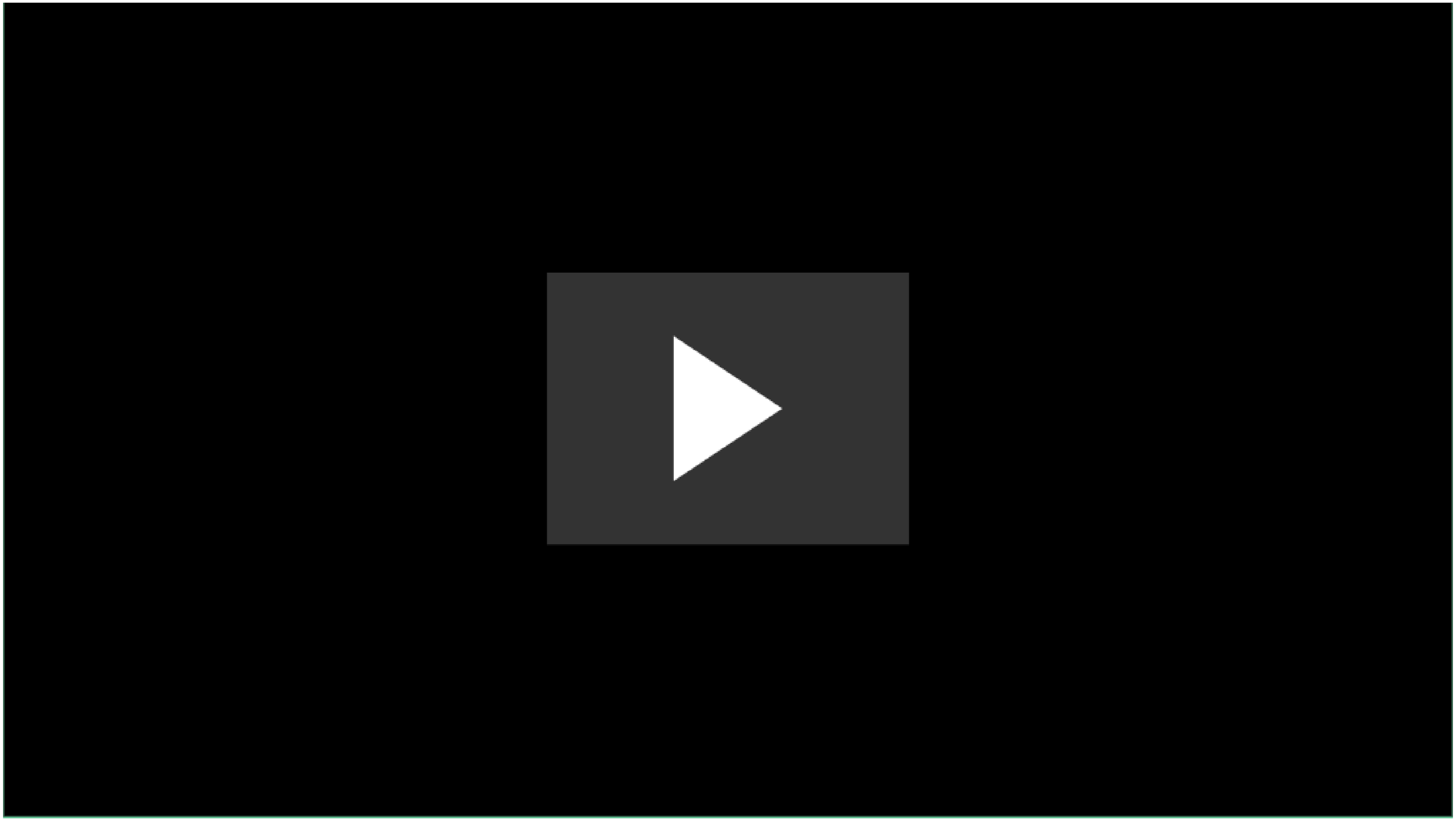


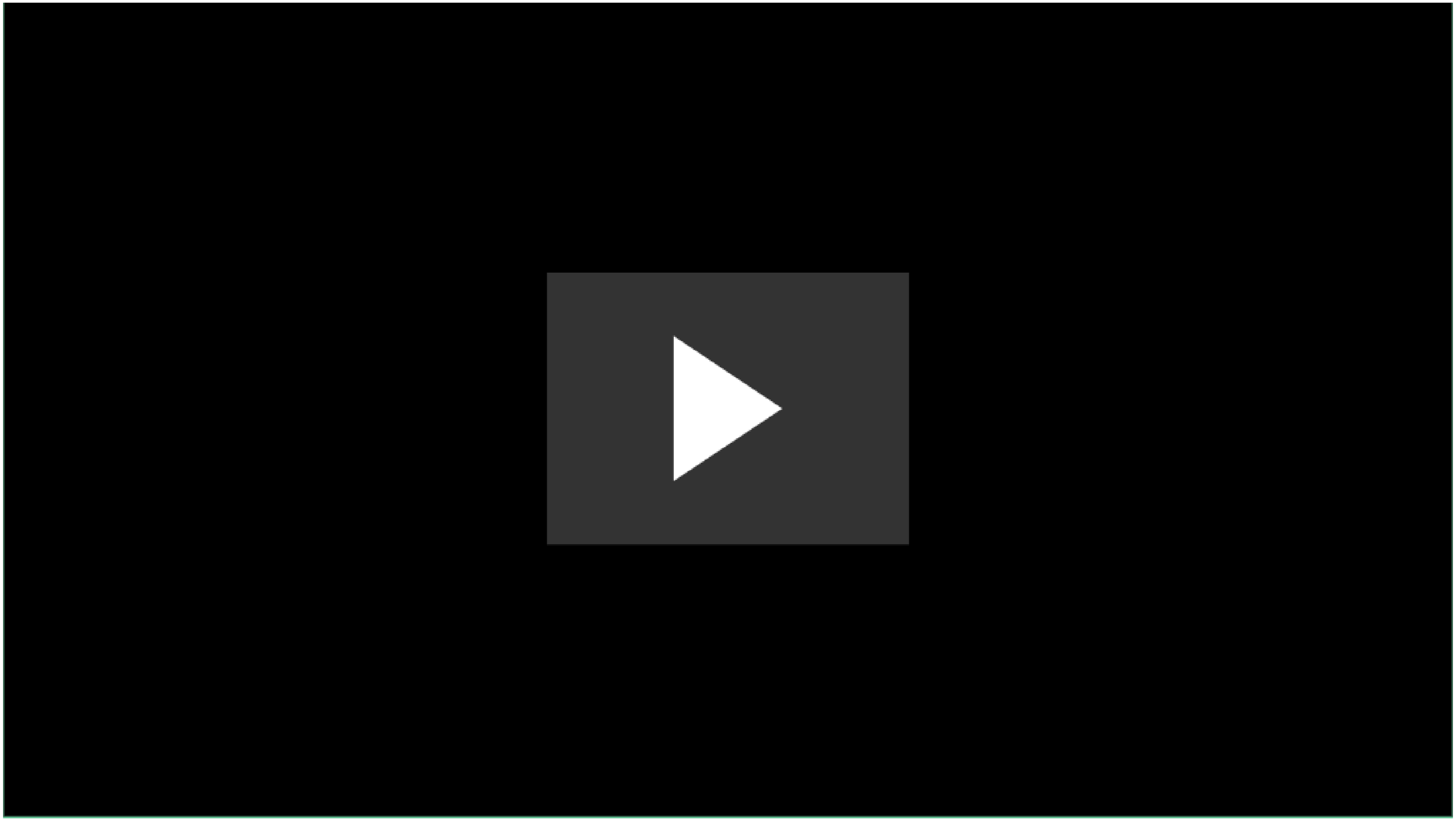
Painting

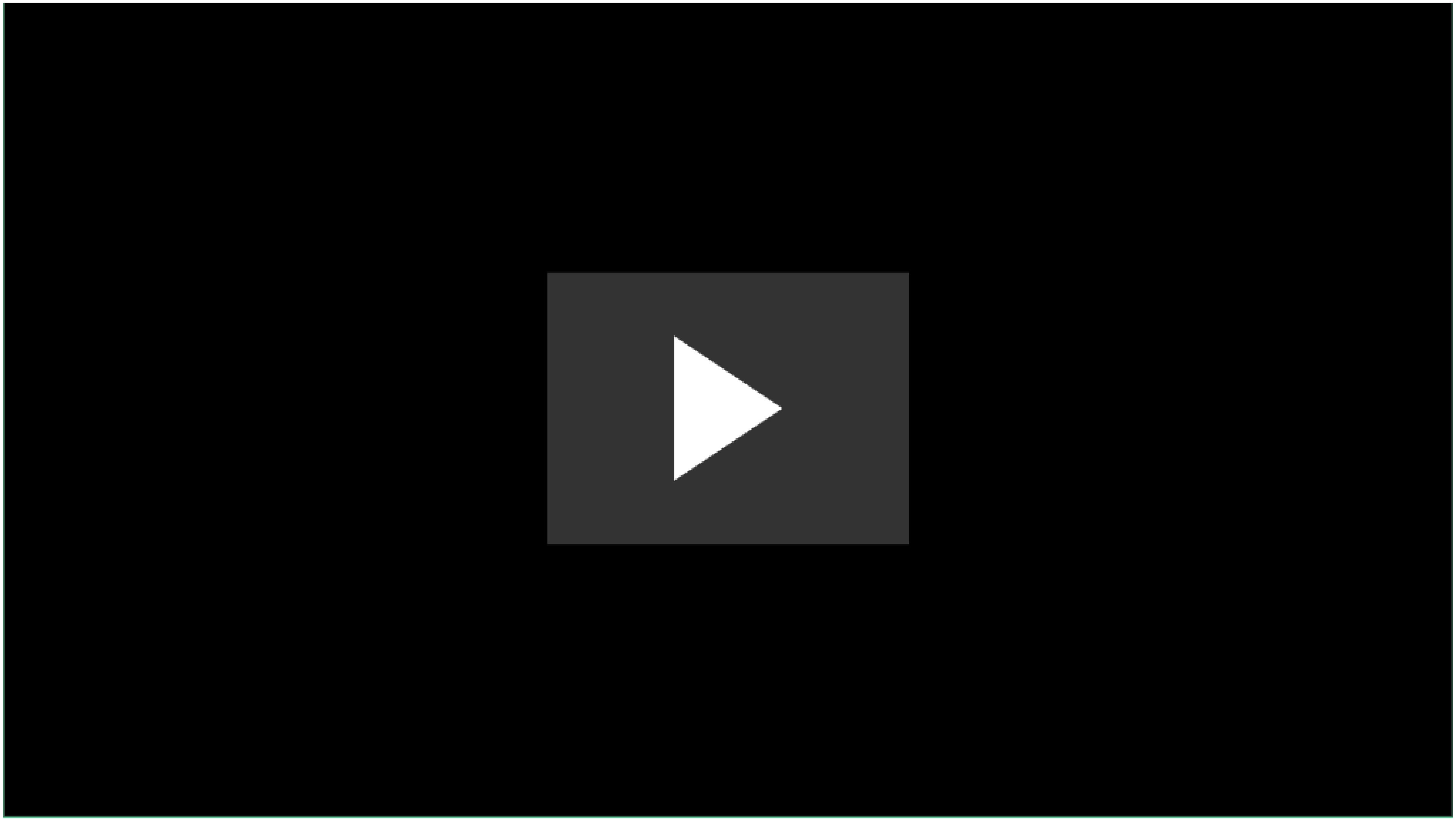
Provided template

Personalizations & Enhancements

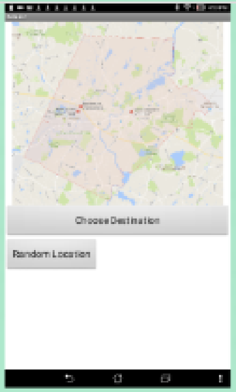


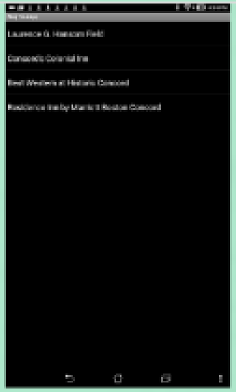






Map Tours

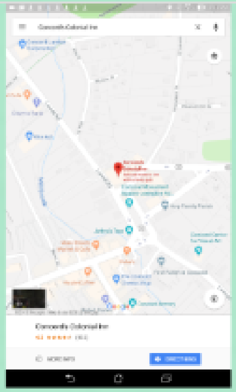


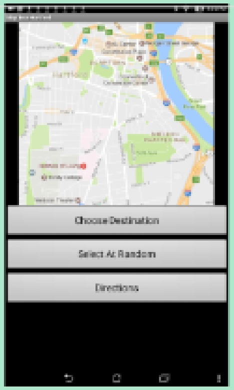

Laurence G. Hanscom Field

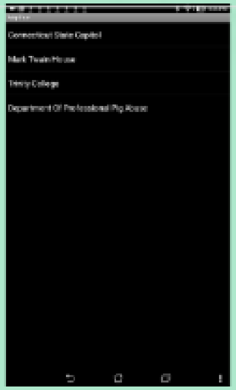
Concord's Colonial Inn

Best Western at Historic Concord

Residence Inn by Marriott Boston Concord



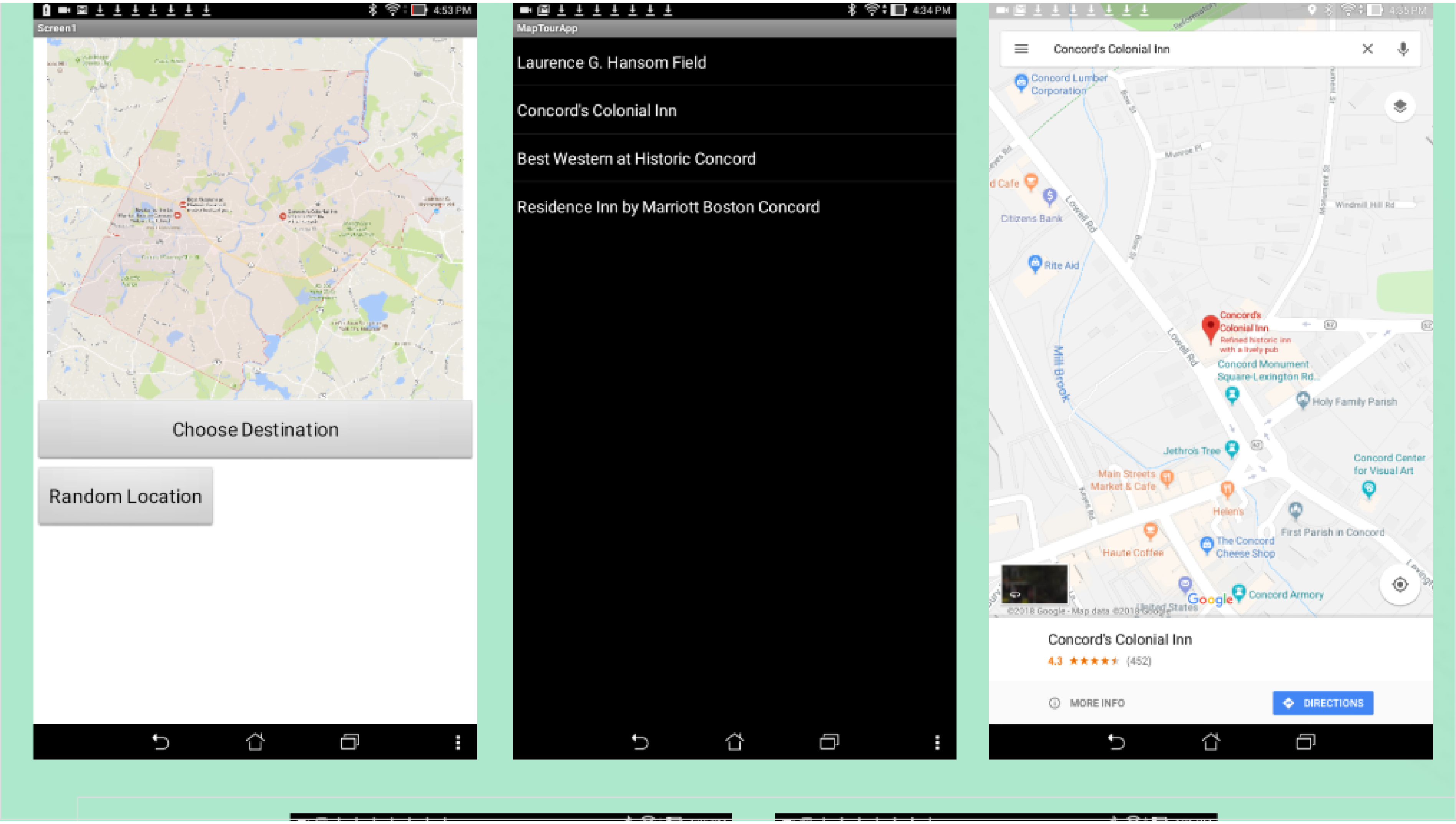



Connecticut State Capitol

Mark Twain House

Trinity College

Department Of Professional Pig Abuse



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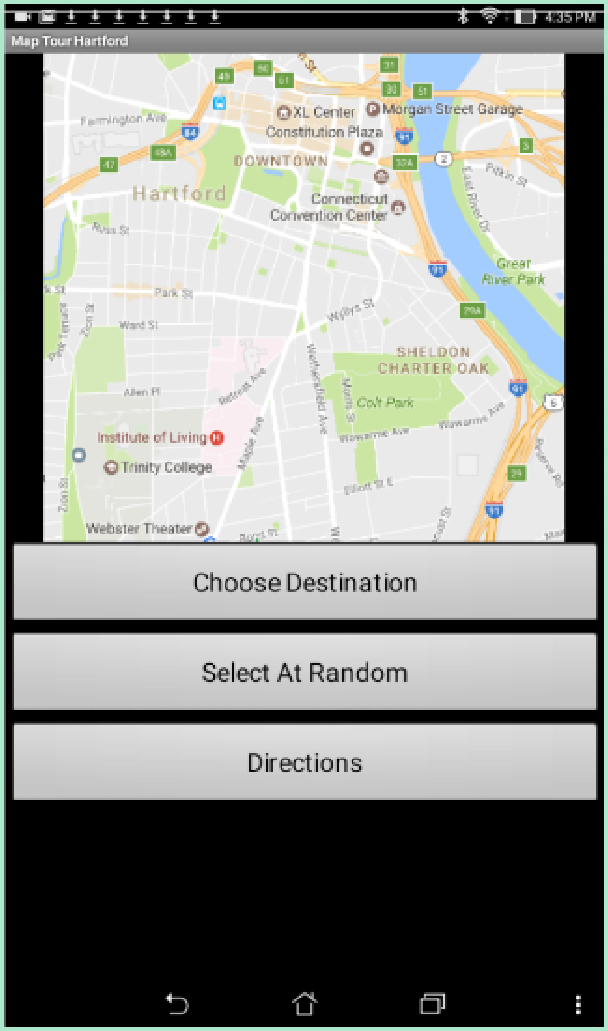

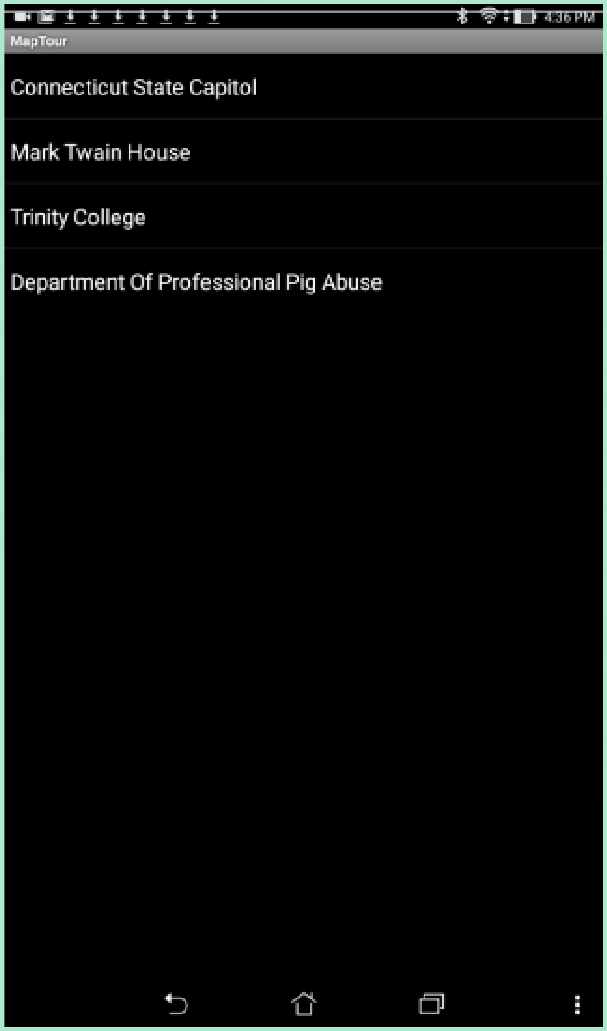

Connecticut State Capitol

Mark Twain House

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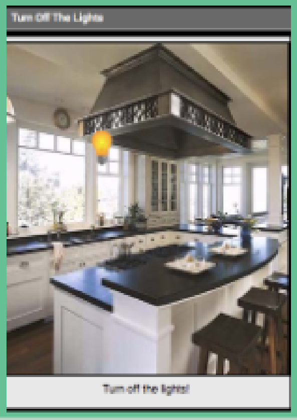
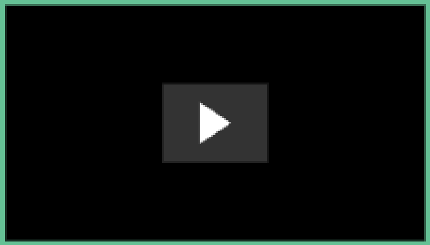
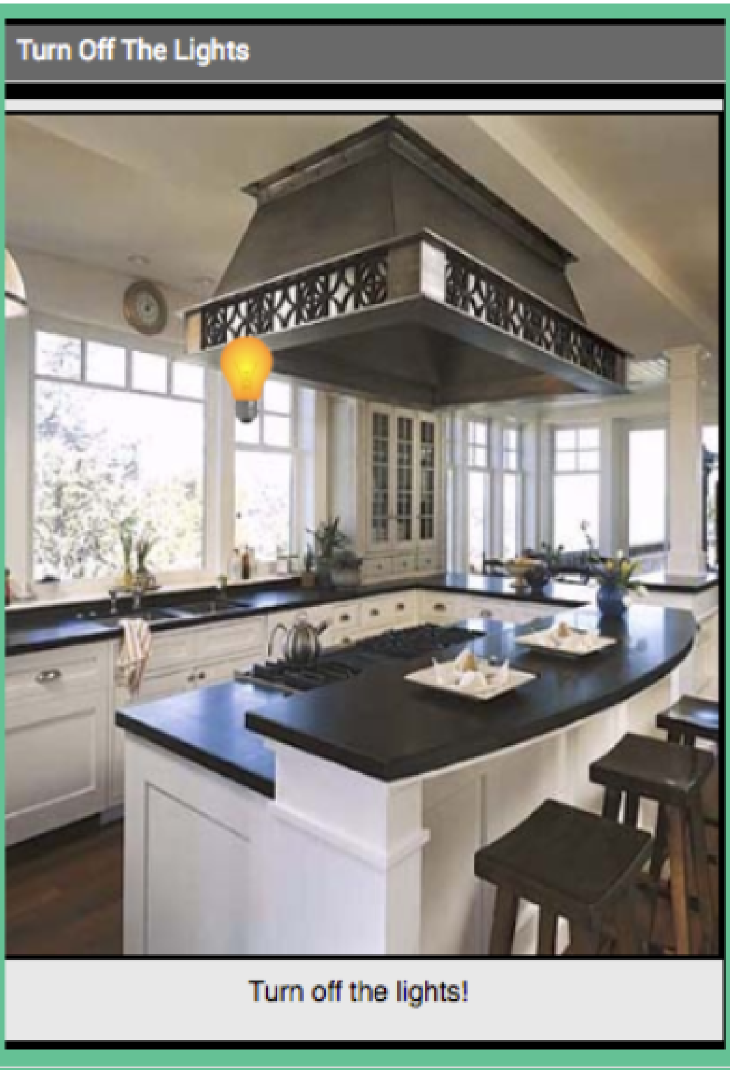
"Lights Out"


Turn Off The Lights

Turn off the lights!

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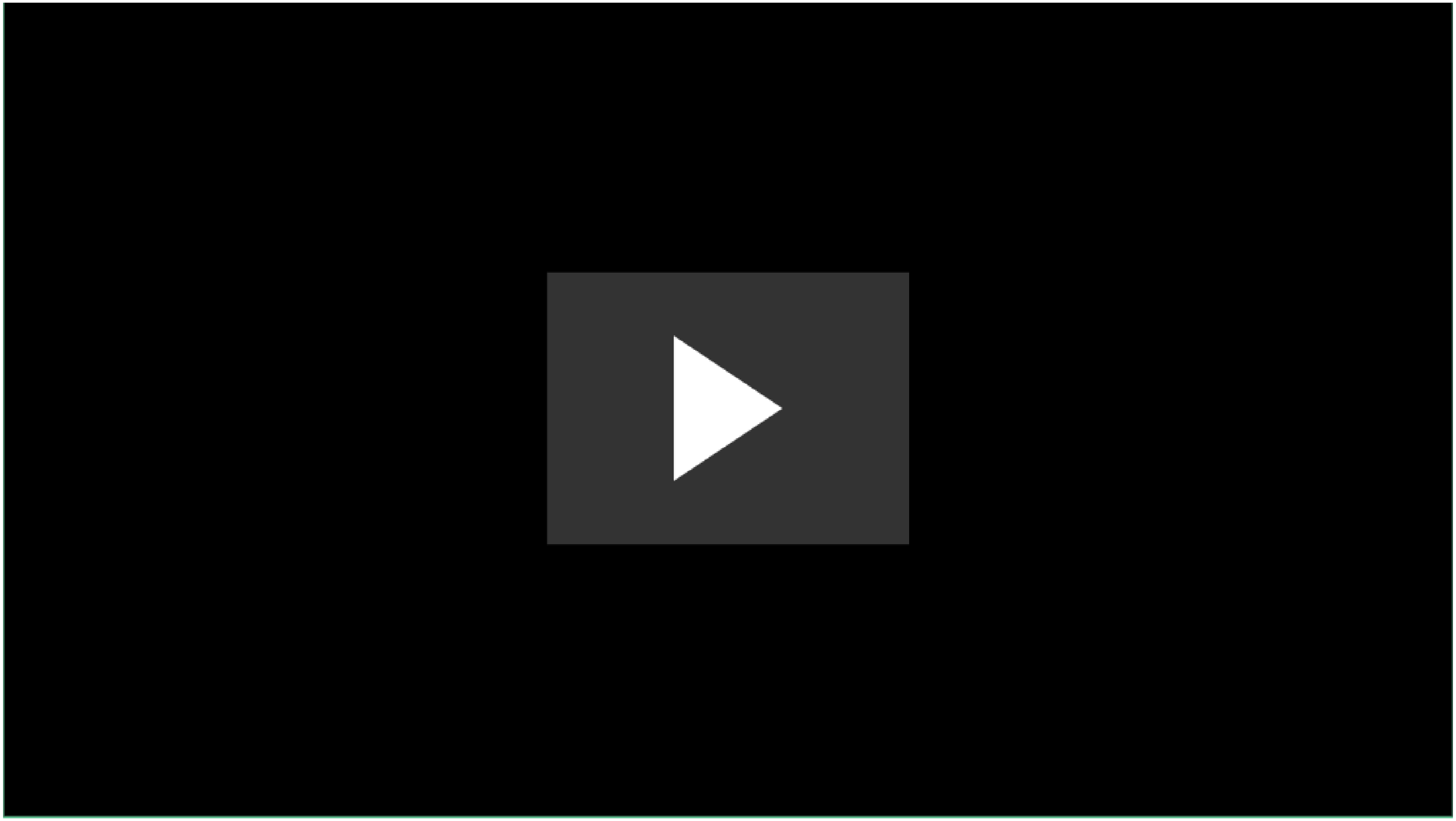
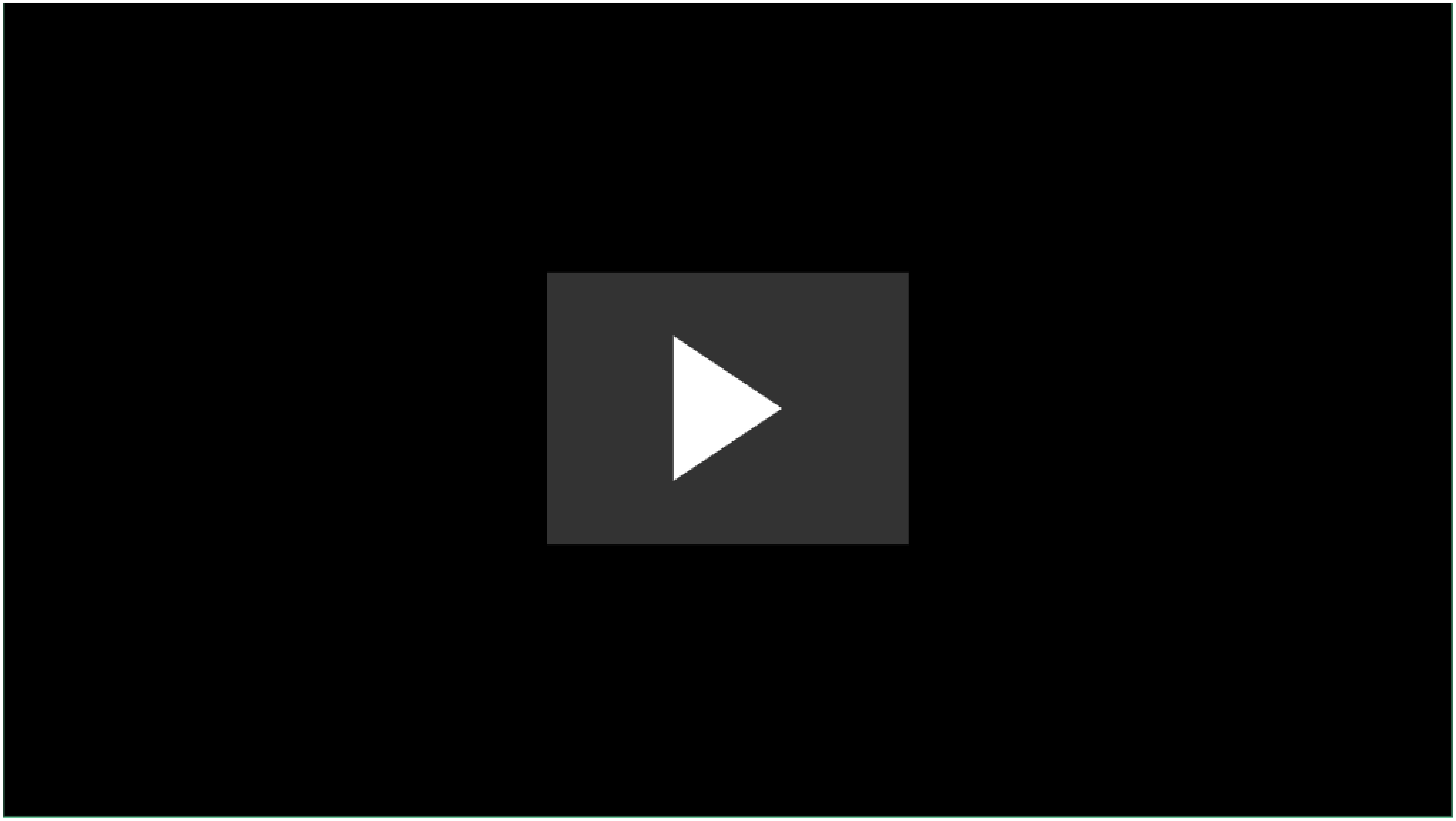
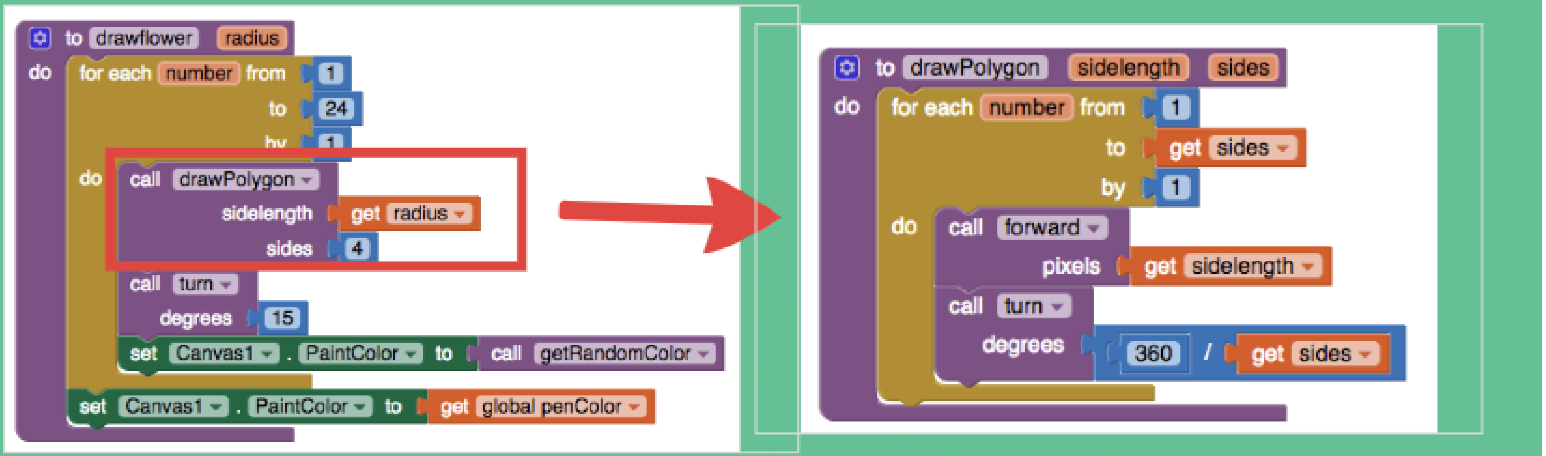


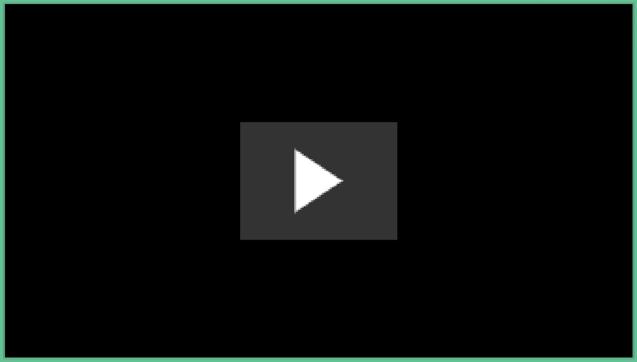


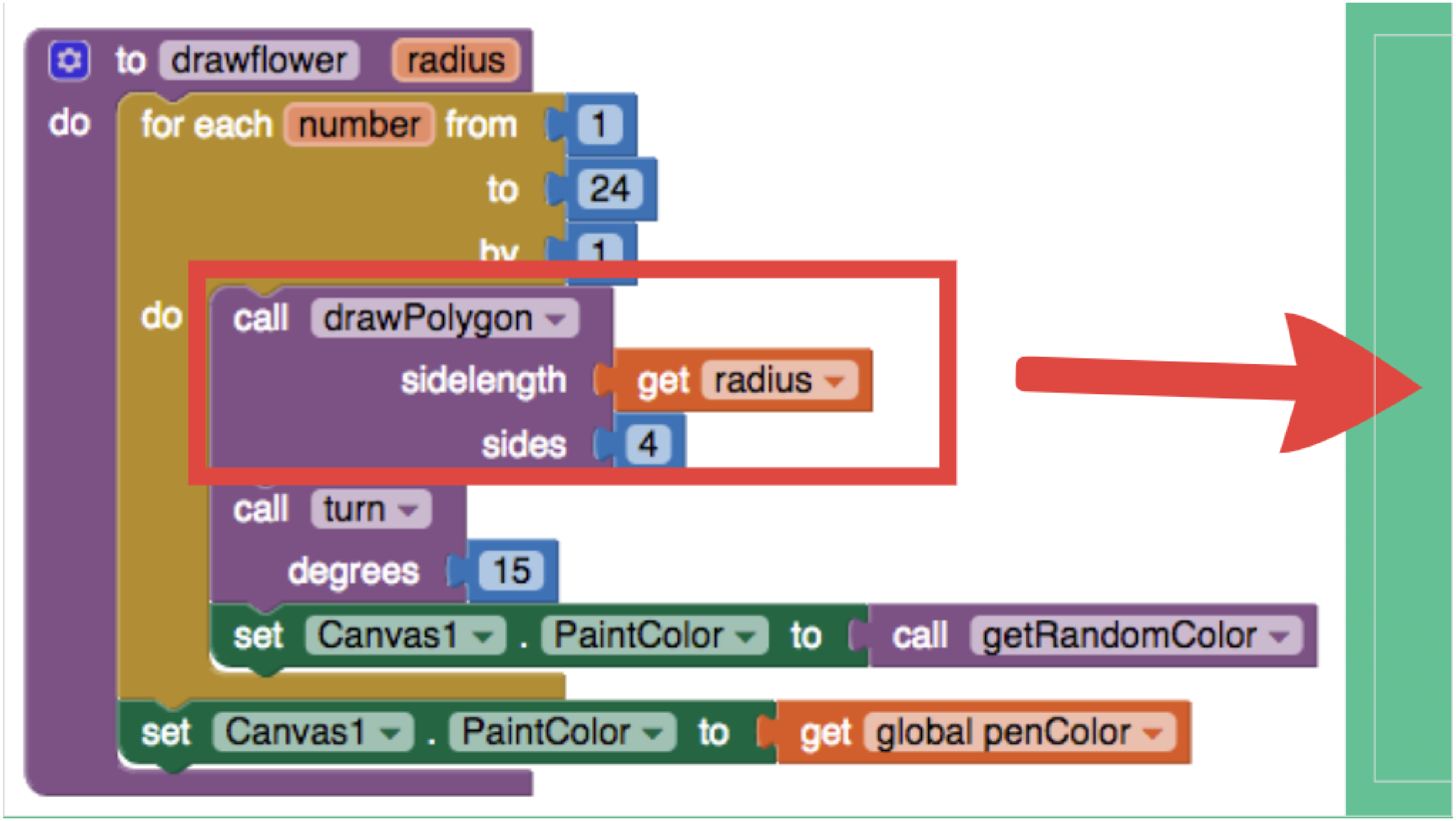
Logo Simulator



```
to drawflower radius
do  for each number from 1
                     to 24
                     by 1
    do  call drawPolygon
             sidelength  get radius
             sides  4
        call turn
             degrees  15
        set Canvas1 . PaintColor to  call getRandomColor
    set Canvas1 . PaintColor to  get global penColor
```

```
to drawPolygon sidelength sides
do  for each number from 1
                     to  get sides
                     by 1
    do  call forward
             pixels  get sidelength
        call turn
             degrees  360 / get sides
```





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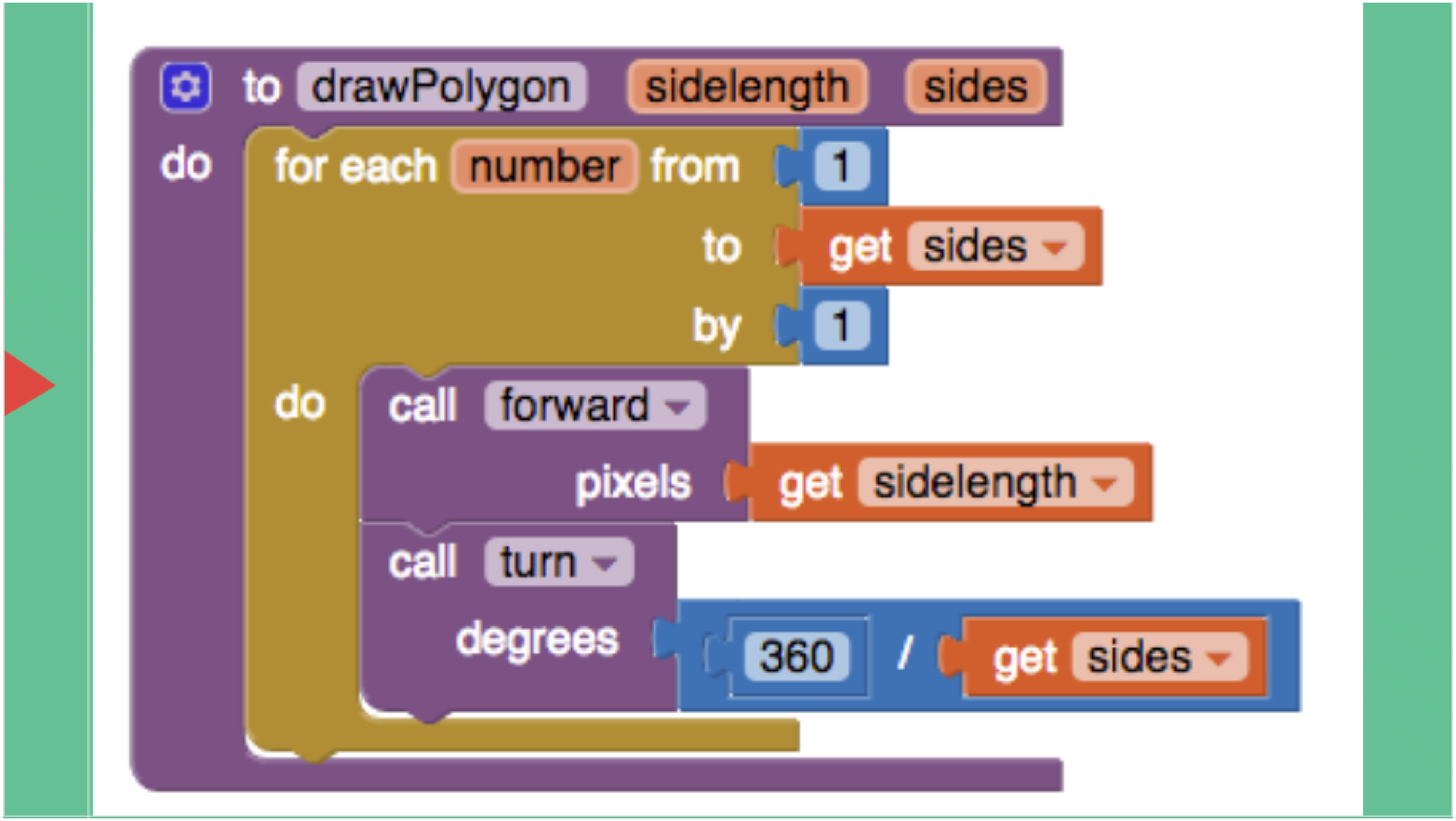
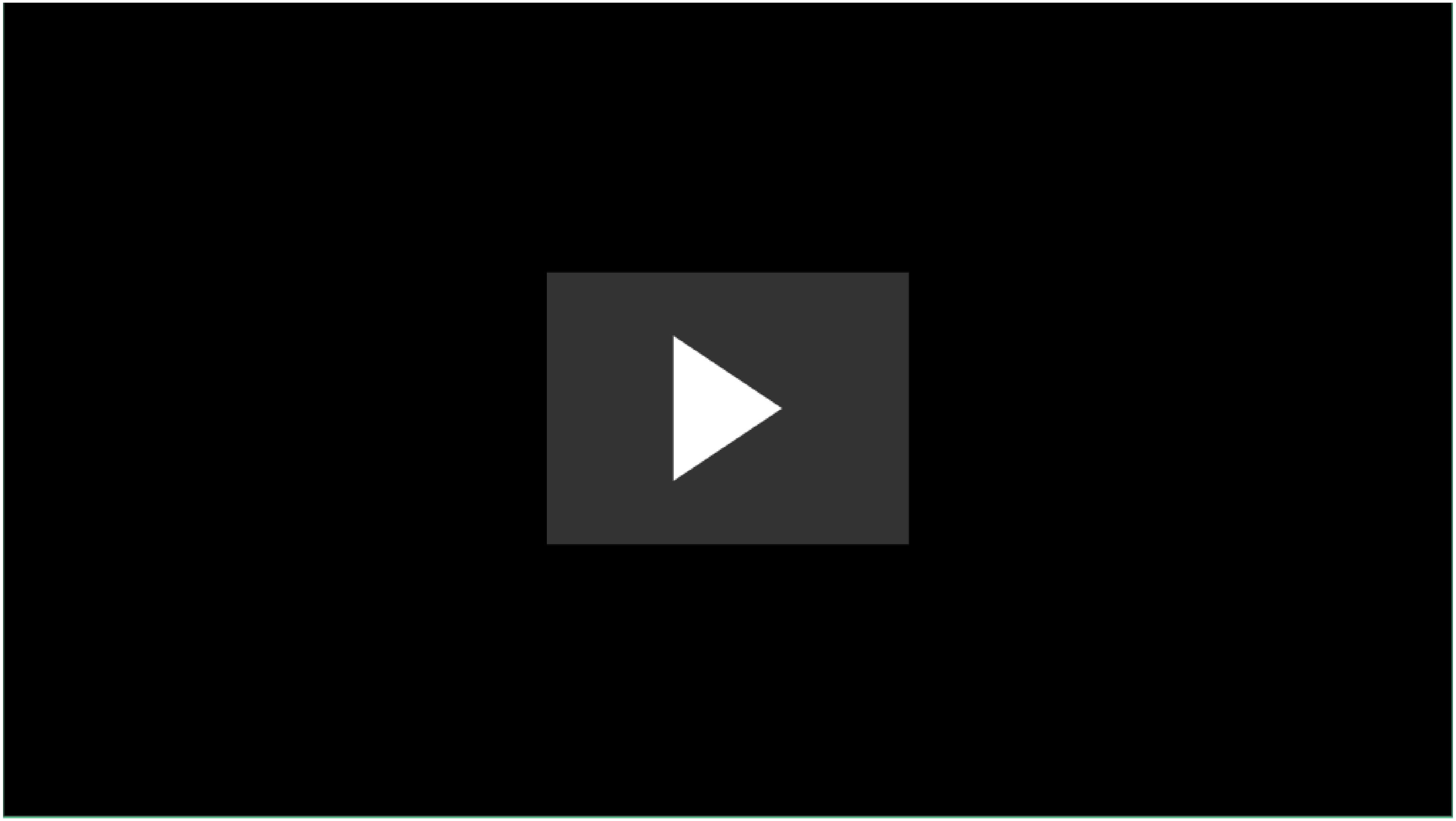
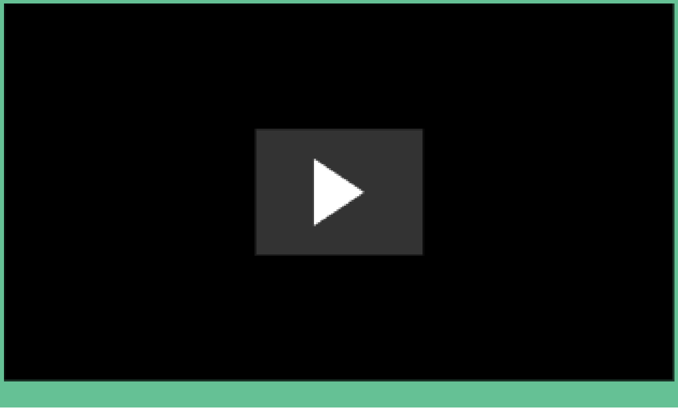
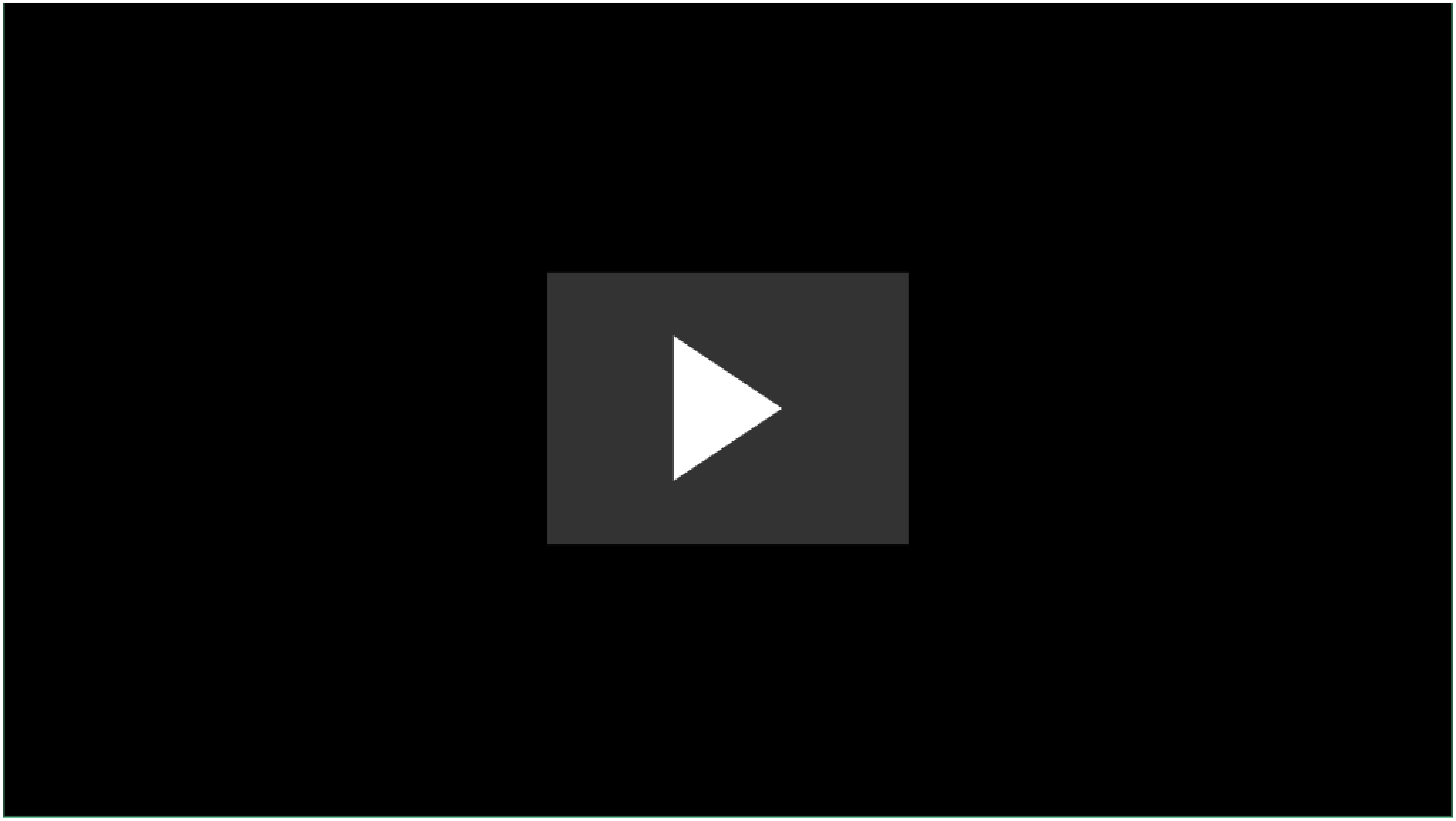


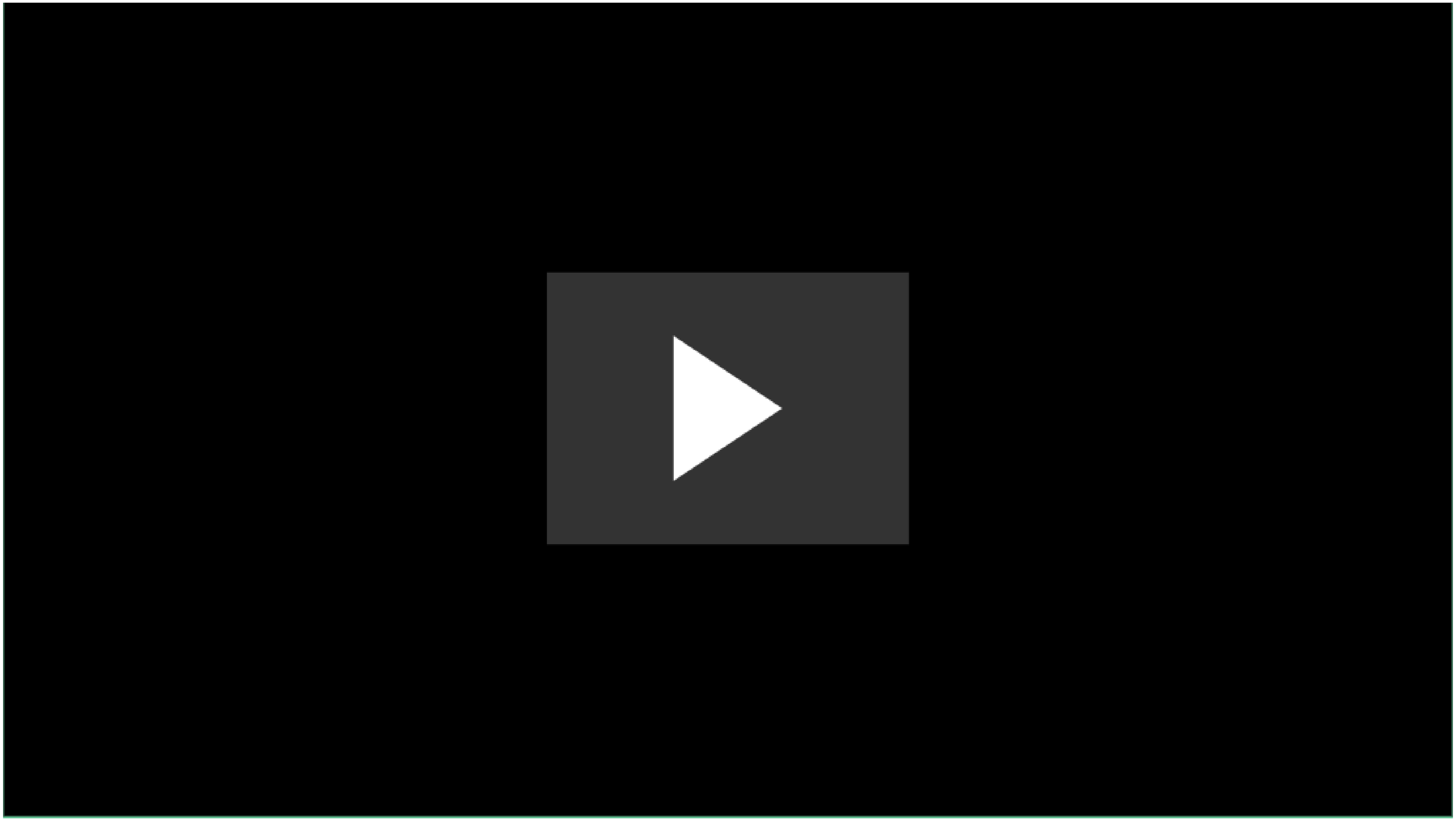
```
to drawPolygon sidelength sides
do  for each number from 1
                      to get sides
                      by 1
    do  call forward
                 pixels get sidelength
        call turn
                 degrees 360 / get sides
```



Quiz Games

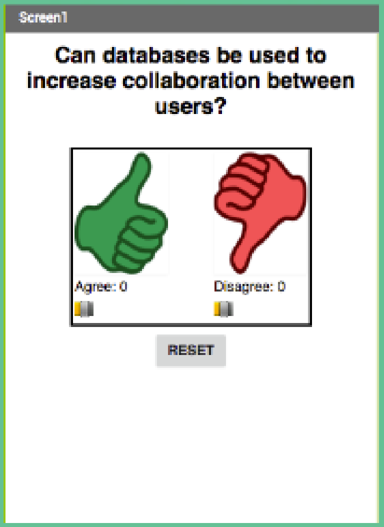


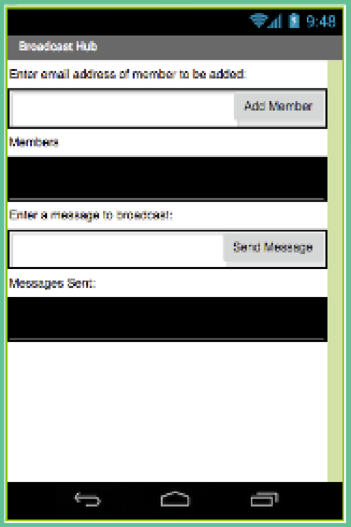




Using Databases

- Clickers with App Inventor's database (TinyWebDB) and Google's Firebase
- E-mail or text Broadcasting Hub


Can databases be used to increase collaboration between users?


9:48
Broadcast Hub
Enter email address of member to be added:
Add Member
Members
Enter a message to broadcast:
Send Message
Messages Sent:

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Math Department Chair

East Haddam, CT

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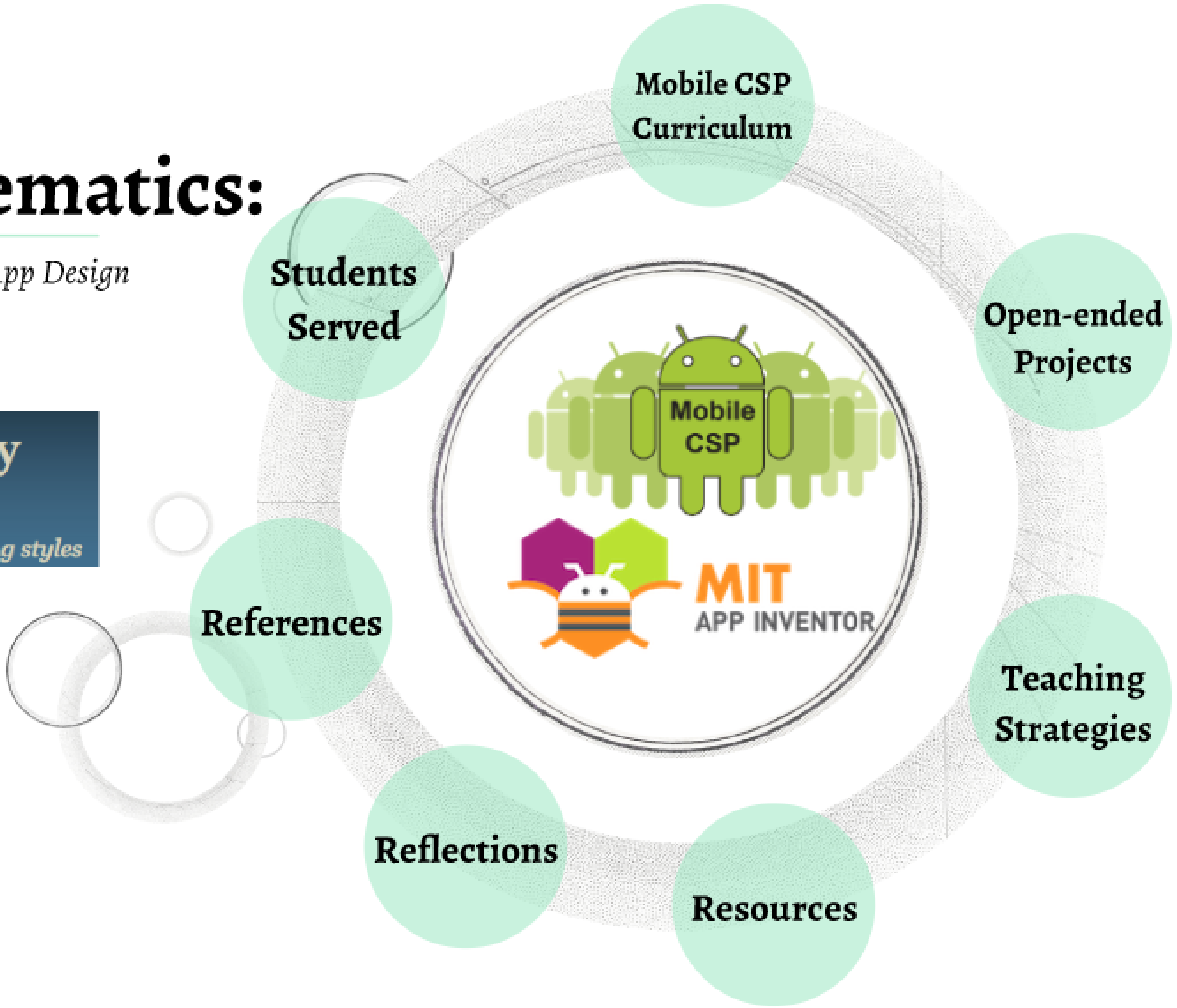

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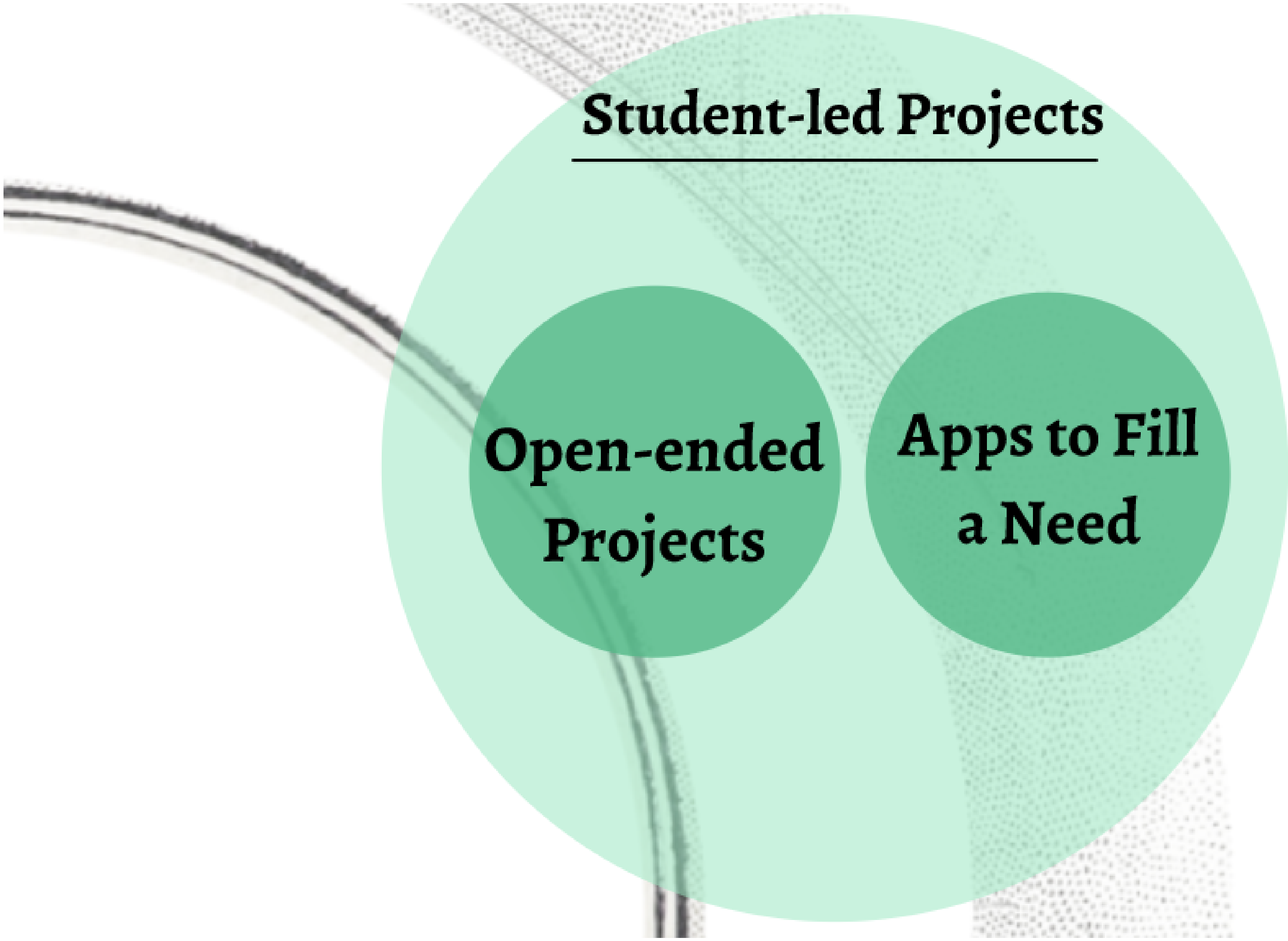
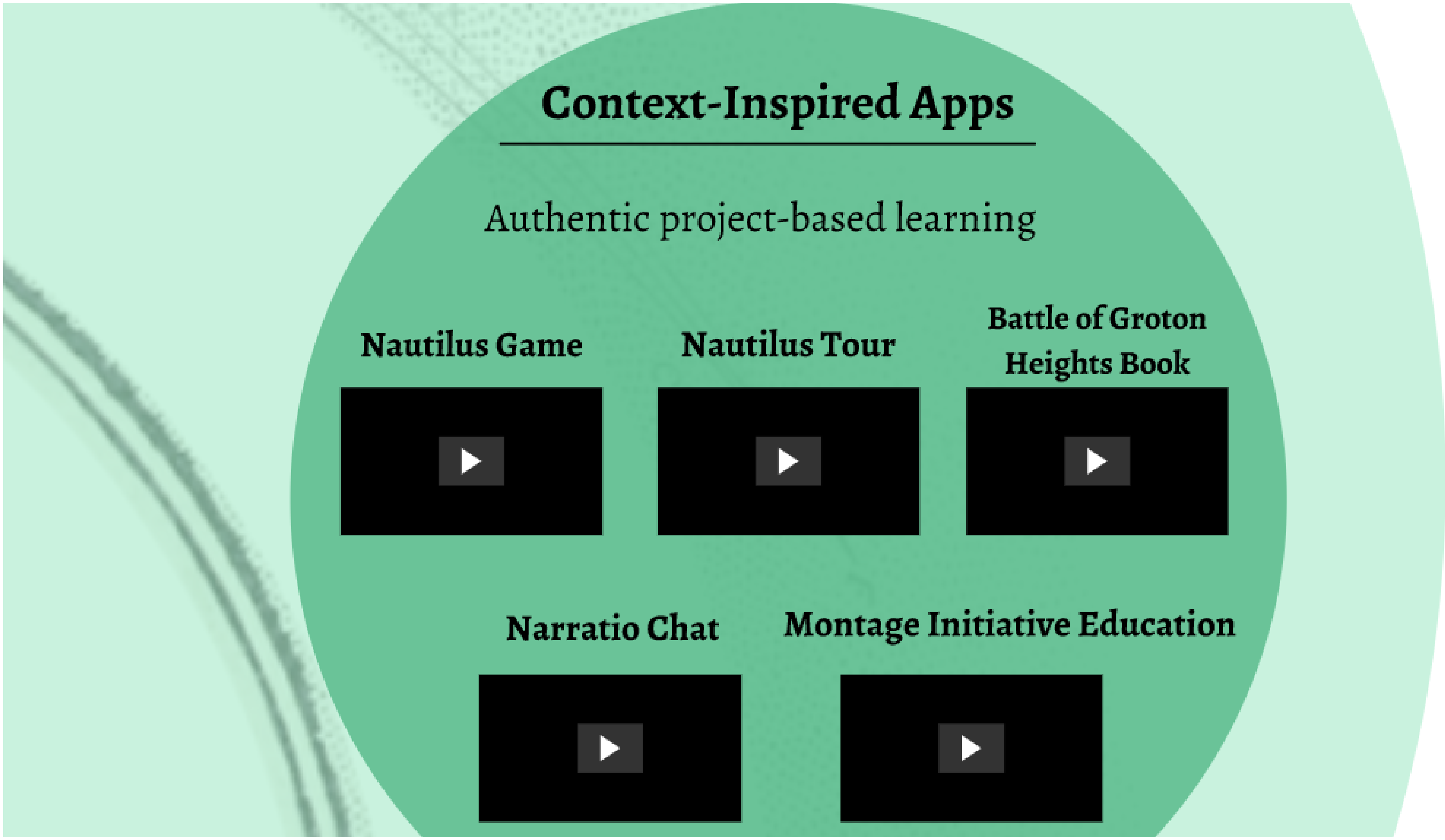


Student-led Projects

Open-ended Projects

Apps to Fill a Need



Context-Inspired Apps

Authentic project-based learning

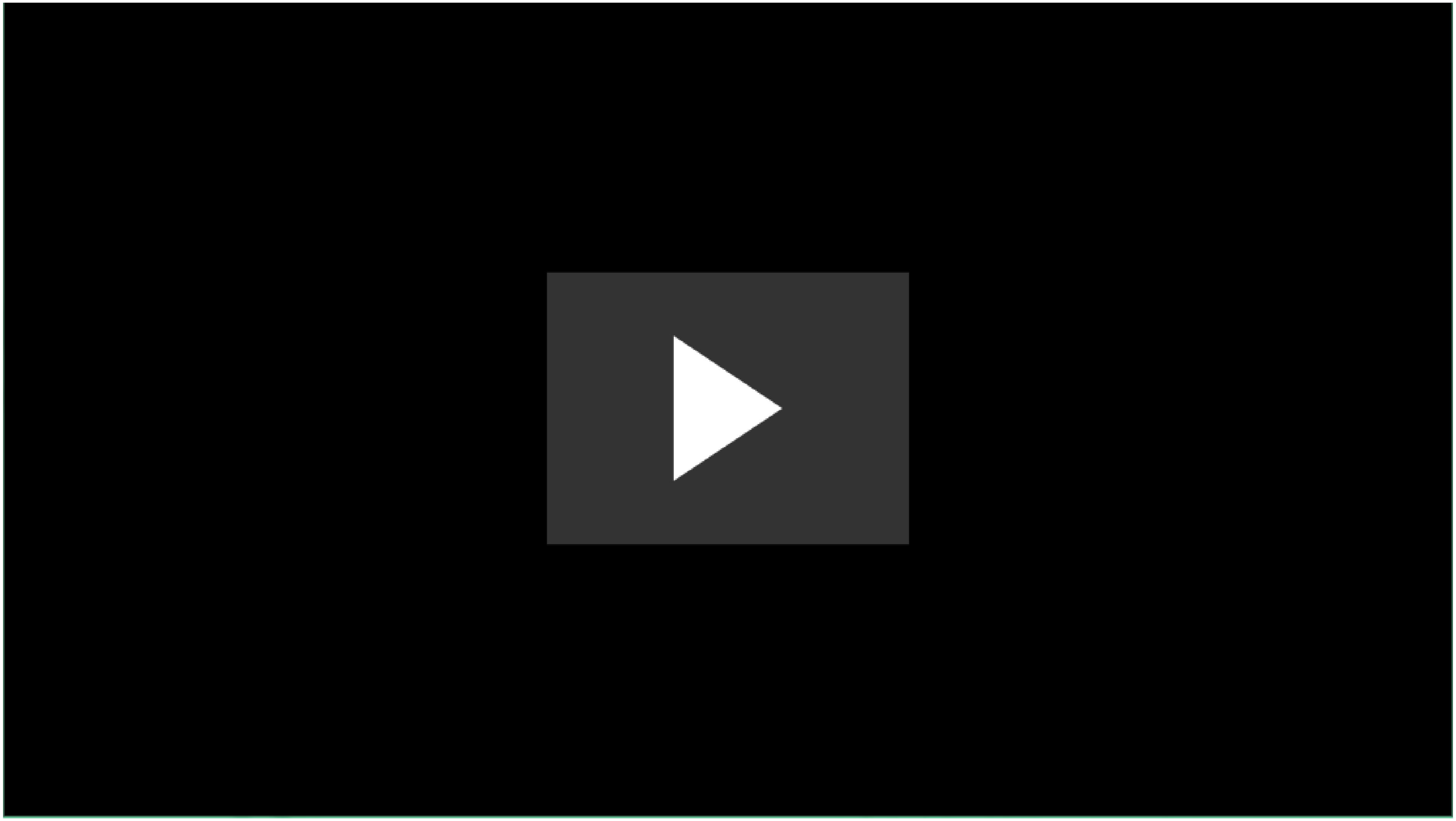
Nautilus Game

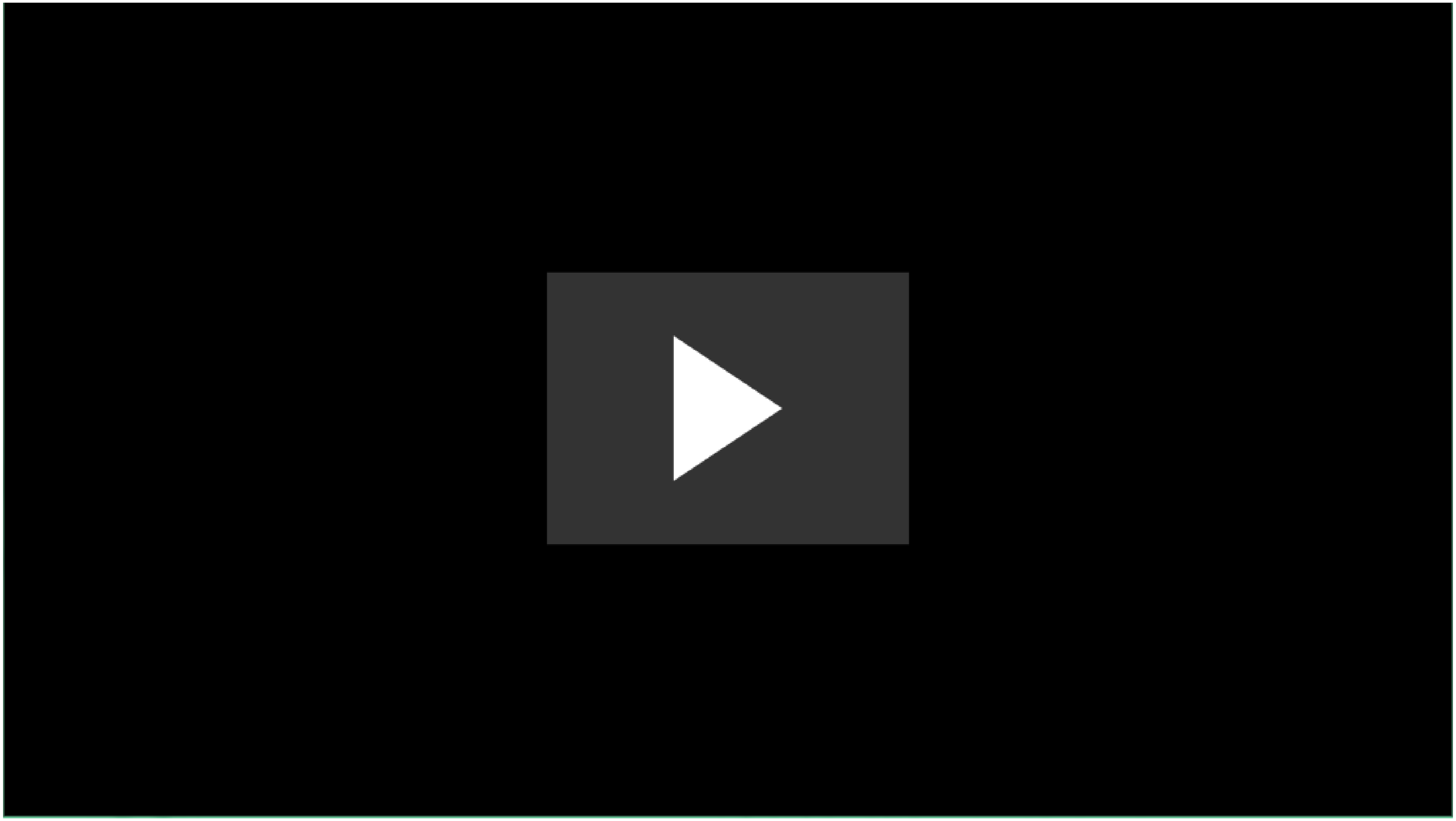
Nautilus Tour

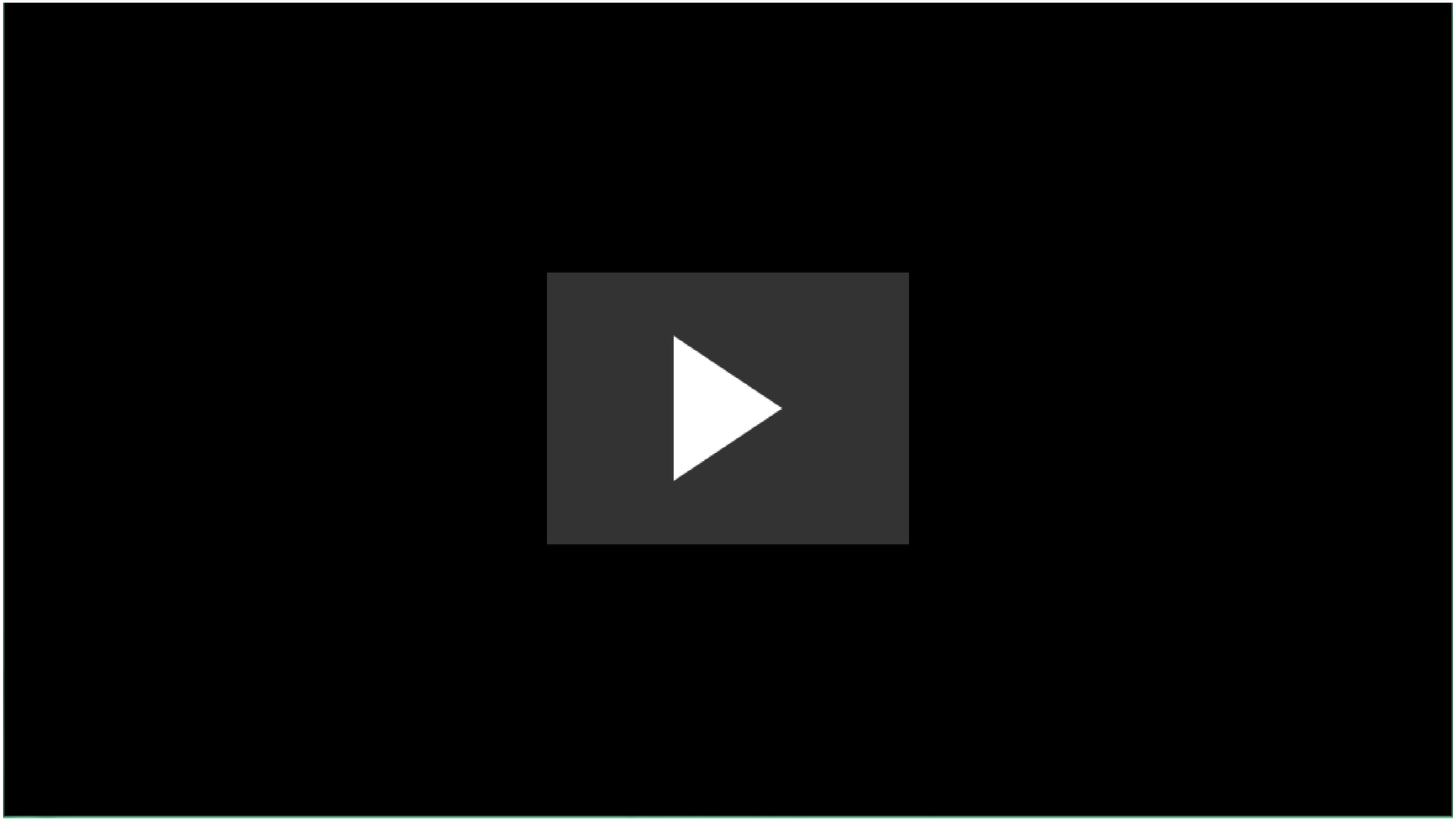
Battle of Groton Heights Book

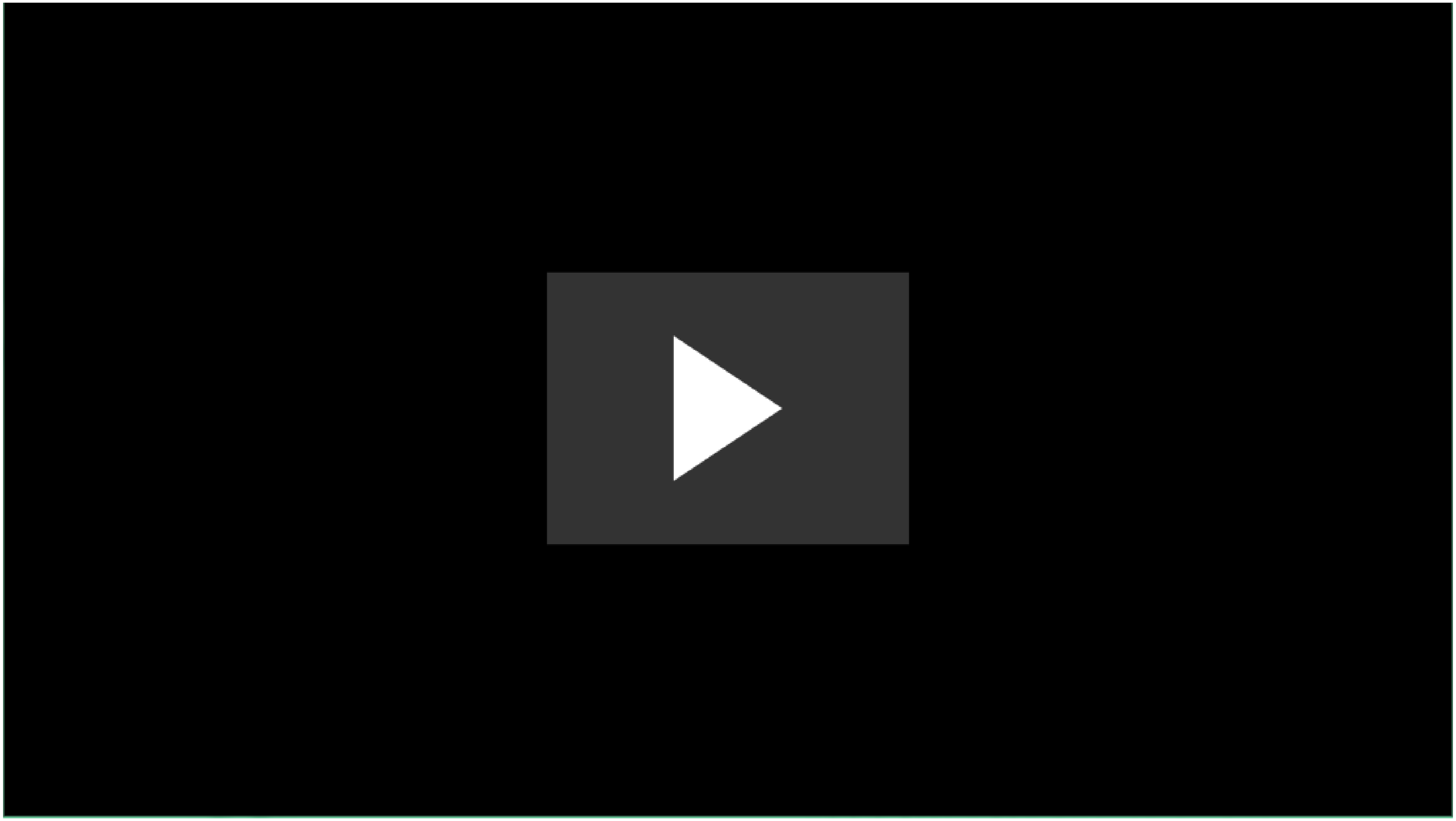
Narratio Chat

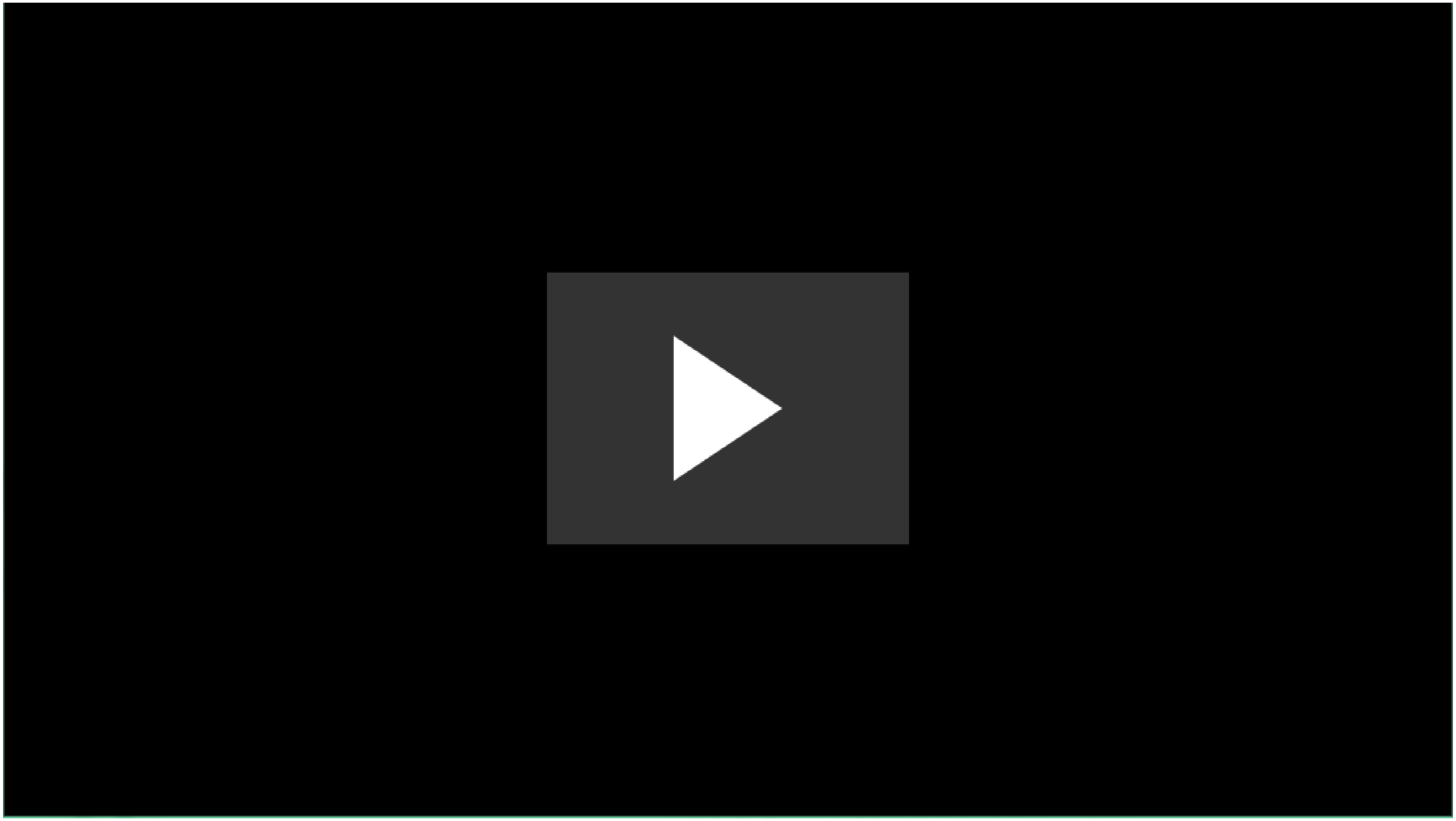
Montage Initiative Education

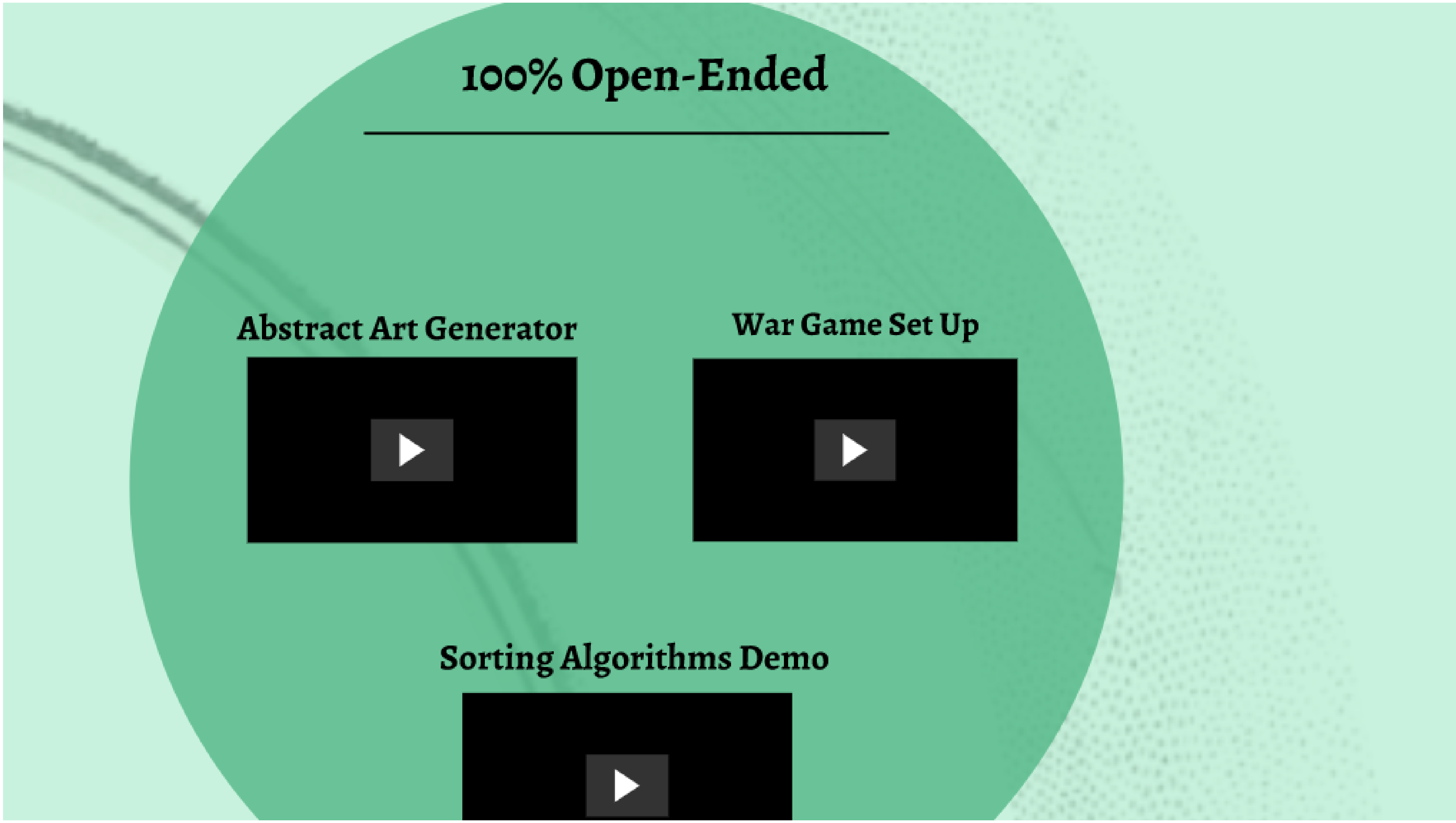










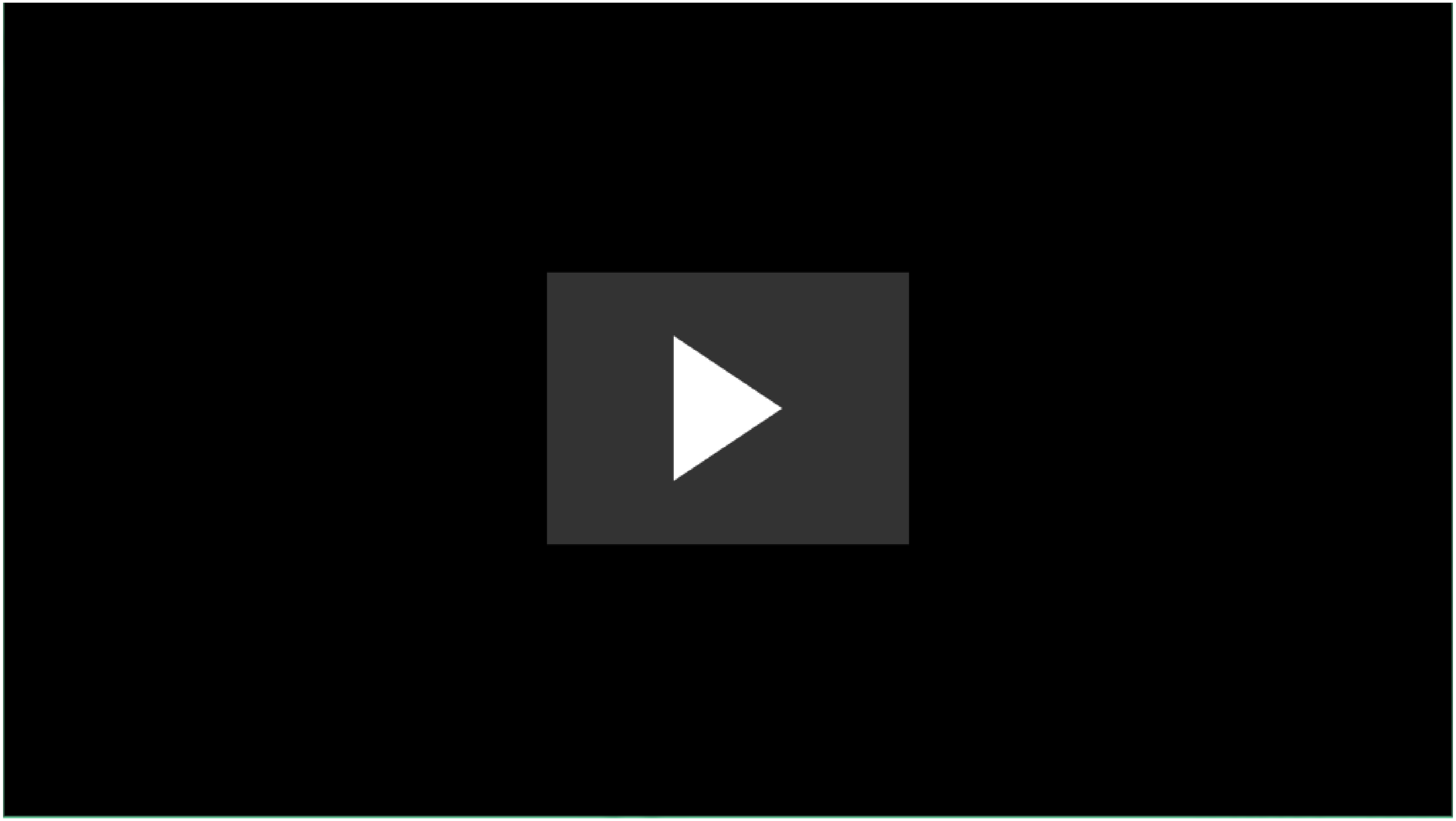


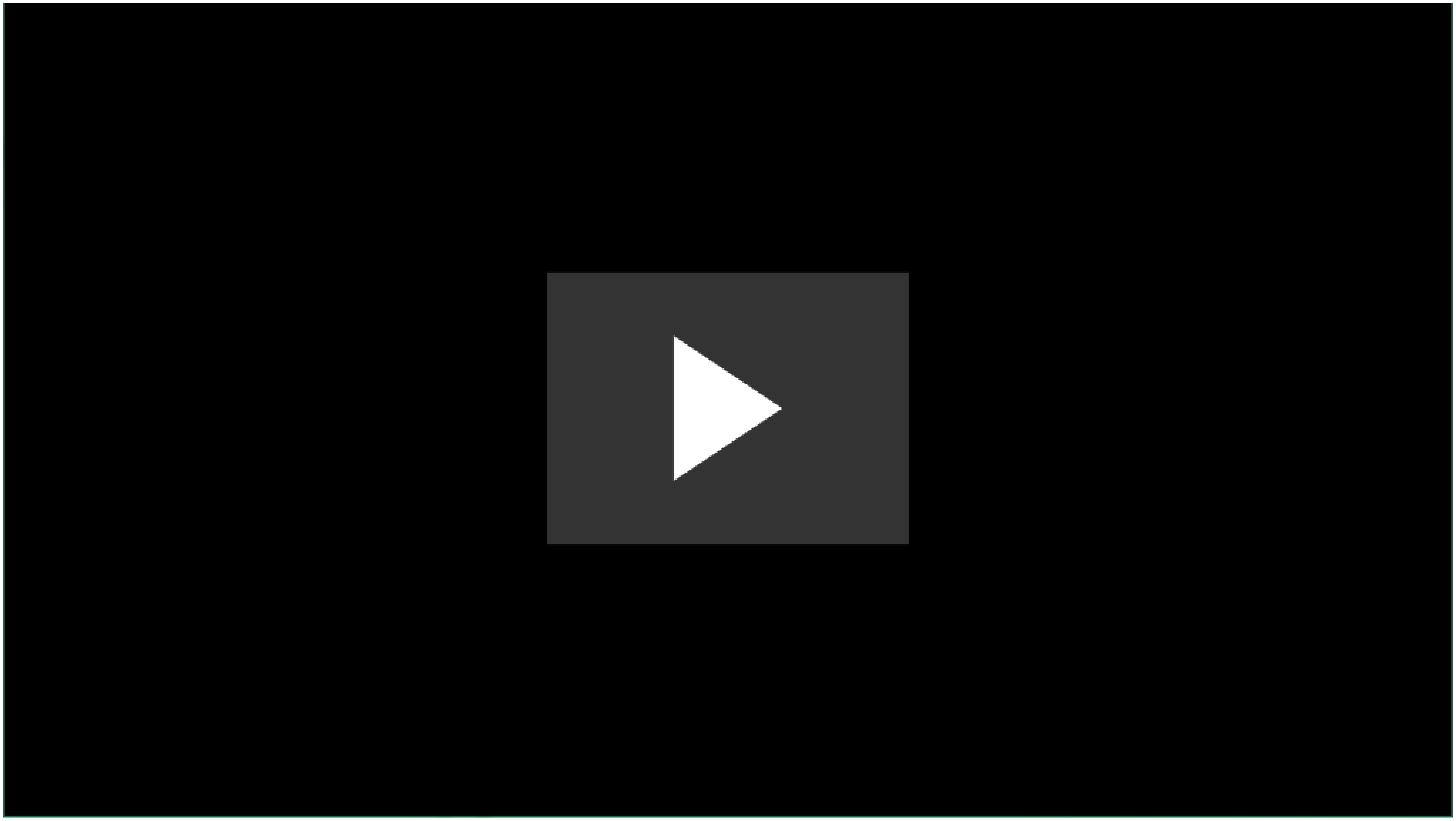
100% Open-Ended

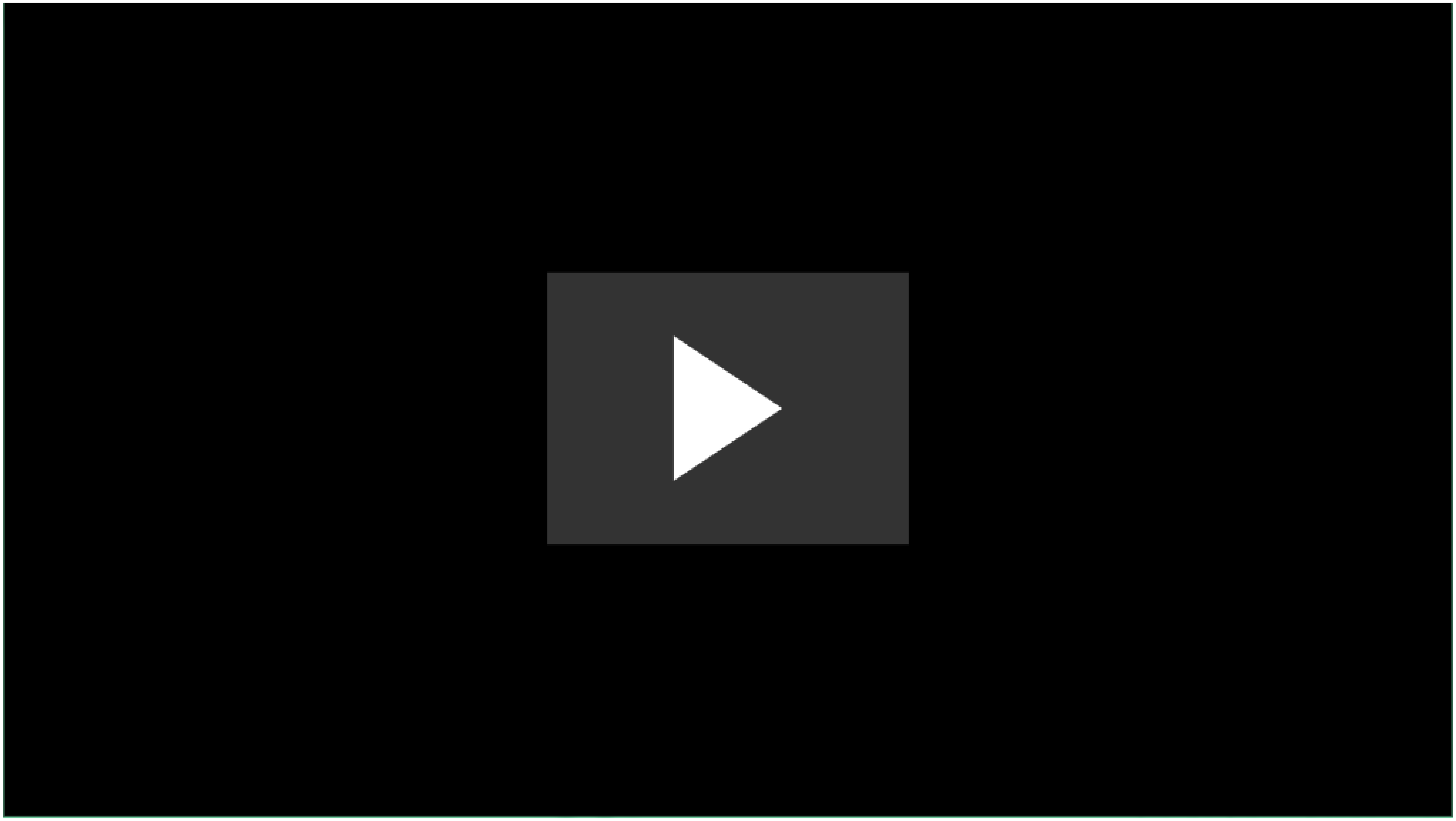
Abstract Art Generator

War Game Set Up

Sorting Algorithms Demo







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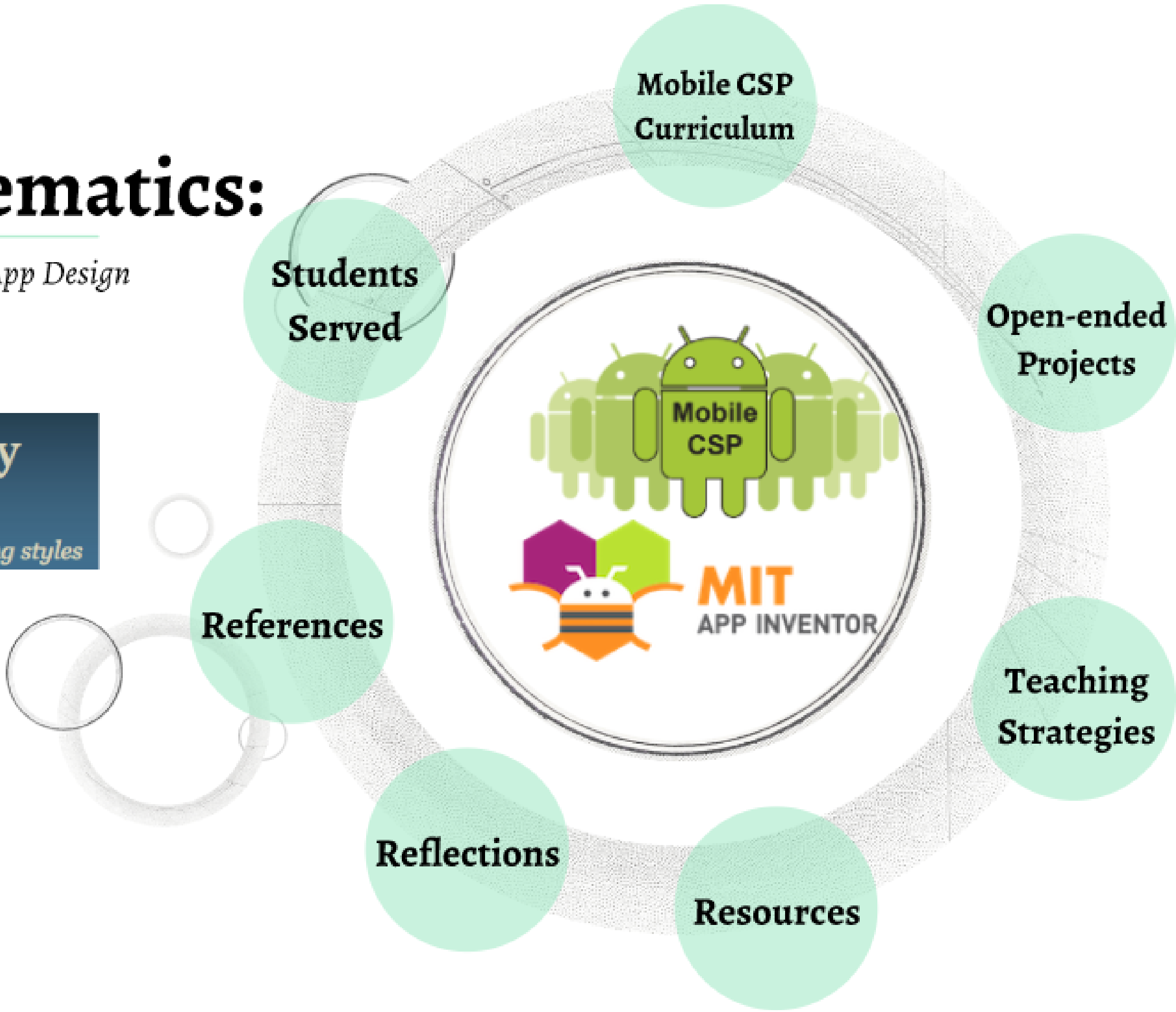

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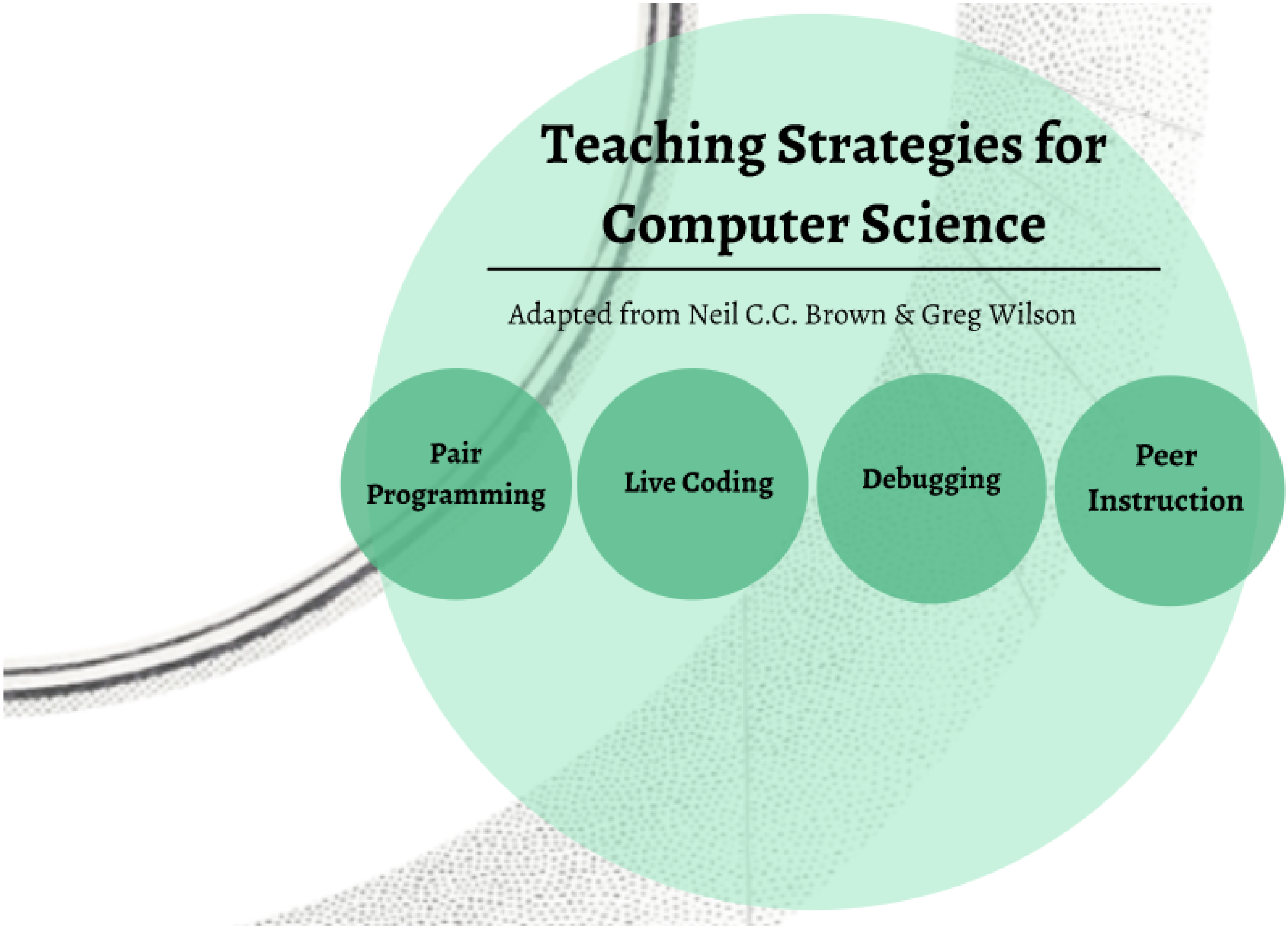


Teaching Strategies for Computer Science

Adapted from Neil C.C. Brown & Greg Wilson

- Pair Programming
- Live Coding
- Debugging
- Peer Instruction

Peer Instruction

1.) Give a mini-lesson or brief overview of concepts

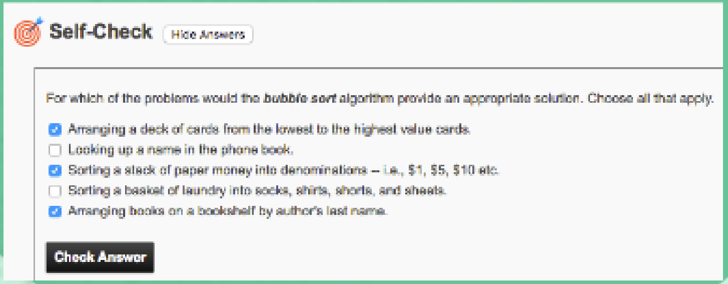
2.) Pose a multiple choice question that 40-60% of students are likely to get right

3.) Students vote individually

4.) Students discuss in small groups

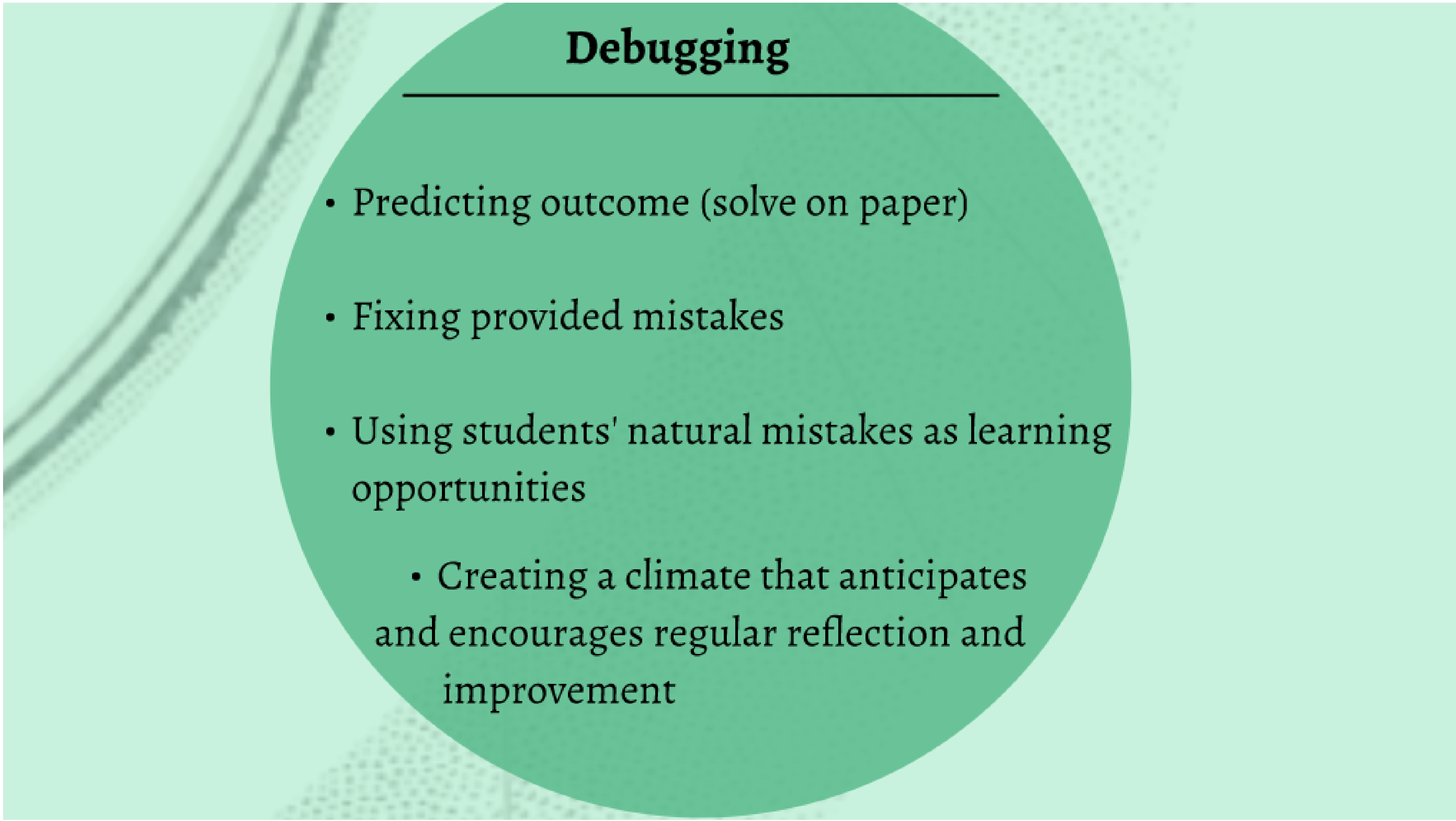
5.) Reconvene and vote again

6.) Respond as needed (move on or clarify)



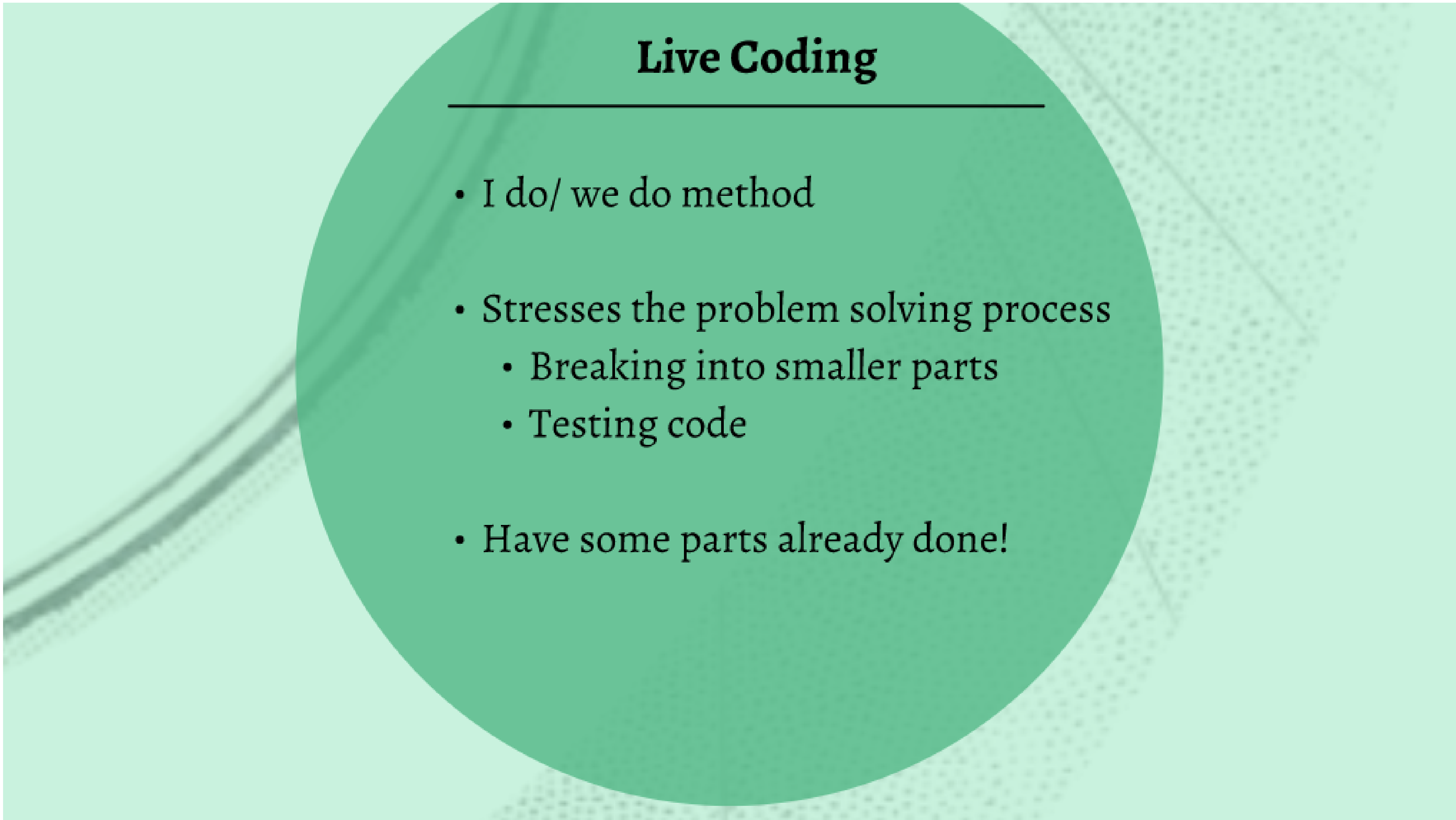
For which of the problems would the *bubble sort* algorithm provide an appropriate solution. Choose all that apply.

☑ Arranging a deck of cards from the lowest to the highest value cards.
□ Looking up a name in the phone book.
☑ Sorting a stack of paper money into denominations – i.e., $1, $5, $10 etc.
□ Sorting a basket of laundry into socks, shirts, shorts, and sheets.
☑ Arranging books on a bookshelf by author's last name.



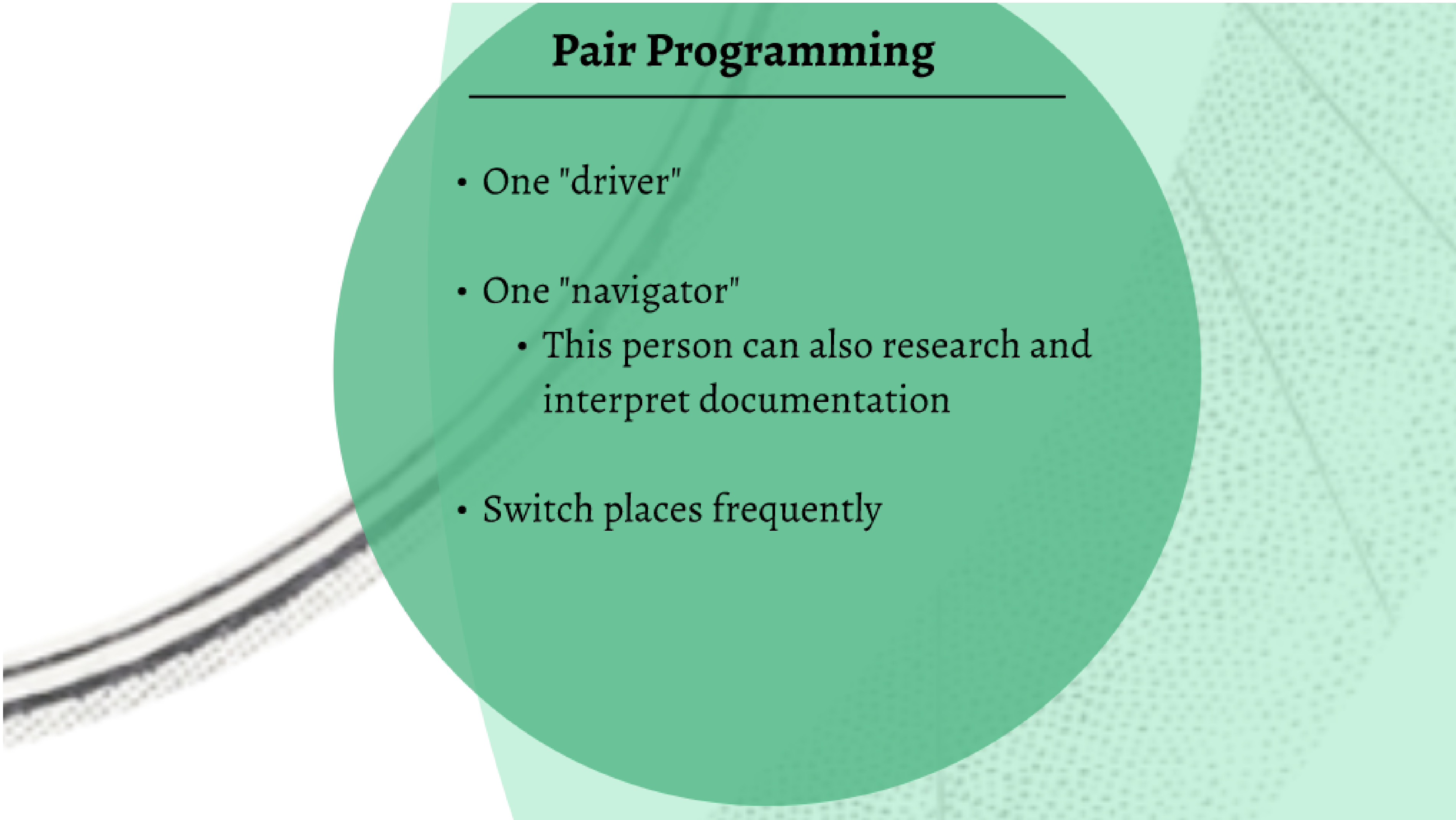
Debugging

- Predicting outcome (solve on paper)
- Fixing provided mistakes
- Using students' natural mistakes as learning opportunities
    - Creating a climate that anticipates and encourages regular reflection and improvement



Live Coding

- I do/ we do method
- Stresses the problem solving process
  - Breaking into smaller parts
  - Testing code
- Have some parts already done!



Pair Programming

- One "driver"
- One "navigator"
  - This person can also research and interpret documentation
- Switch places frequently

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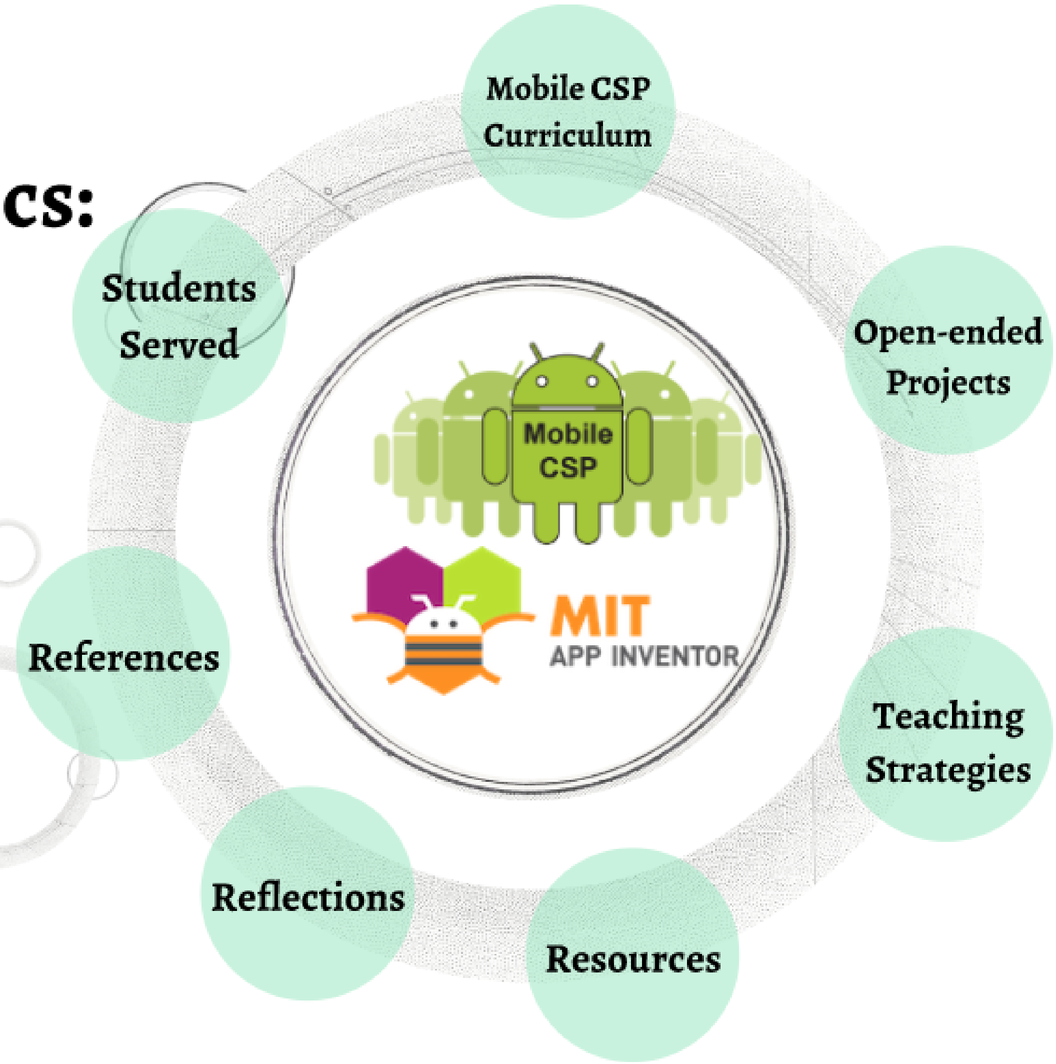

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- Infy.com/Pathfinders

Take the course yourself over the summer!

Free curriculum:

- Mobile CSP -- nice videos, should create your own questions
- Code.org -- works with iPhone, has https://code.org/curriculum/algebra
- Beauty and Joy of Computing - all text-based, Snap! (not apps) https://csforallteachers.org/group/bjcile
- CS50 AP-- most rigorous

Using App Inventor

App Inventor Requirements

- A Google account (one account/file)
- Can run emulator on PC or OSX 10.12 or before (not High Sierra)
  - Otherwise use BlueStacks emulator
- Android device or tablet (~$100) that can use same wifi connection as computer
- iOS version "coming soon"

http://www.appinventor.org/book2

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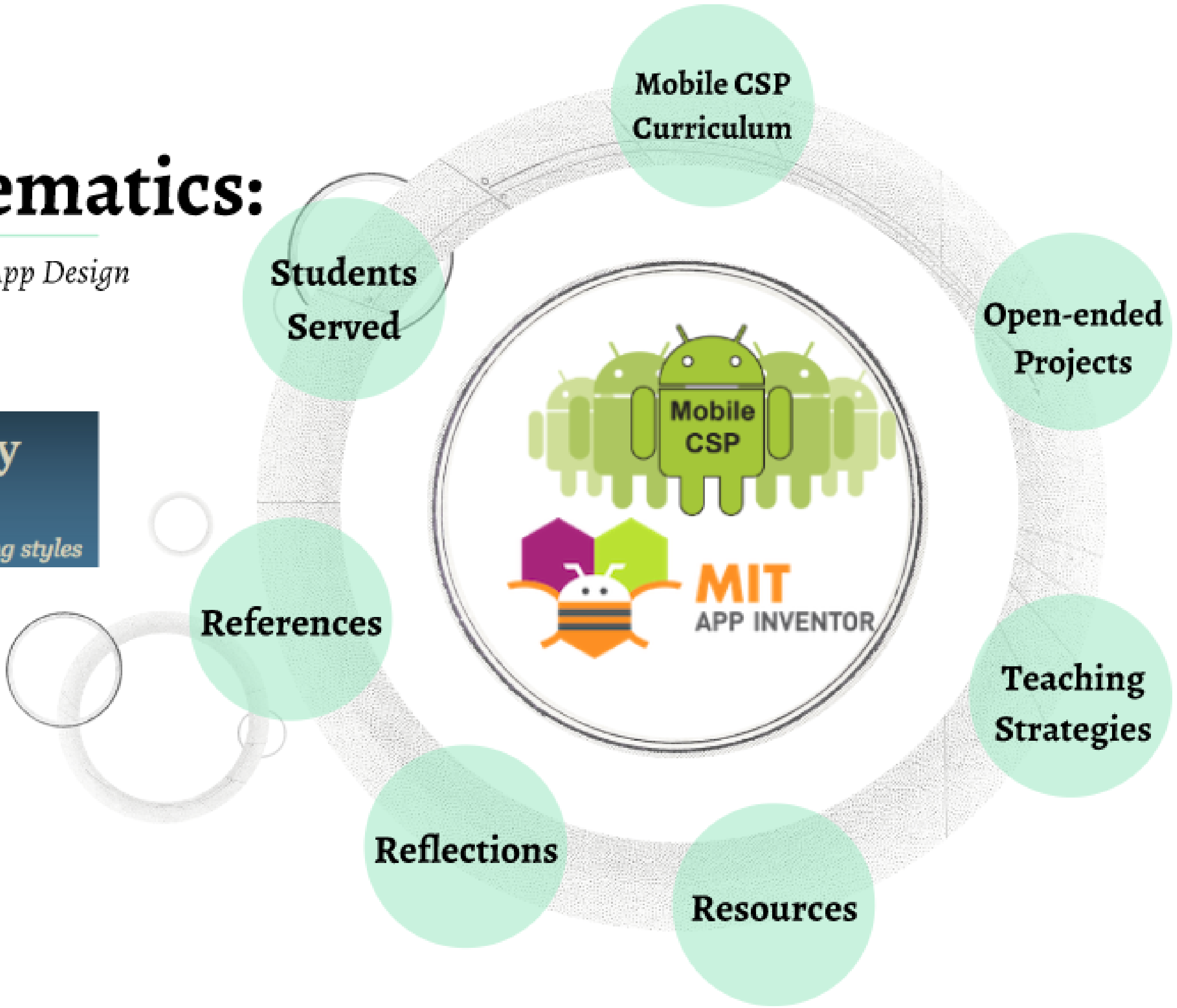

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Reflections

- AP?
- Best for younger students
- Lots of writing, little programming

- Don't use website/portfolio question format

- Multiple choice -> class discussion exercises
- Pre-make some of the step-by-step apps OR live code as a class

- Prepare for tech setbacks!

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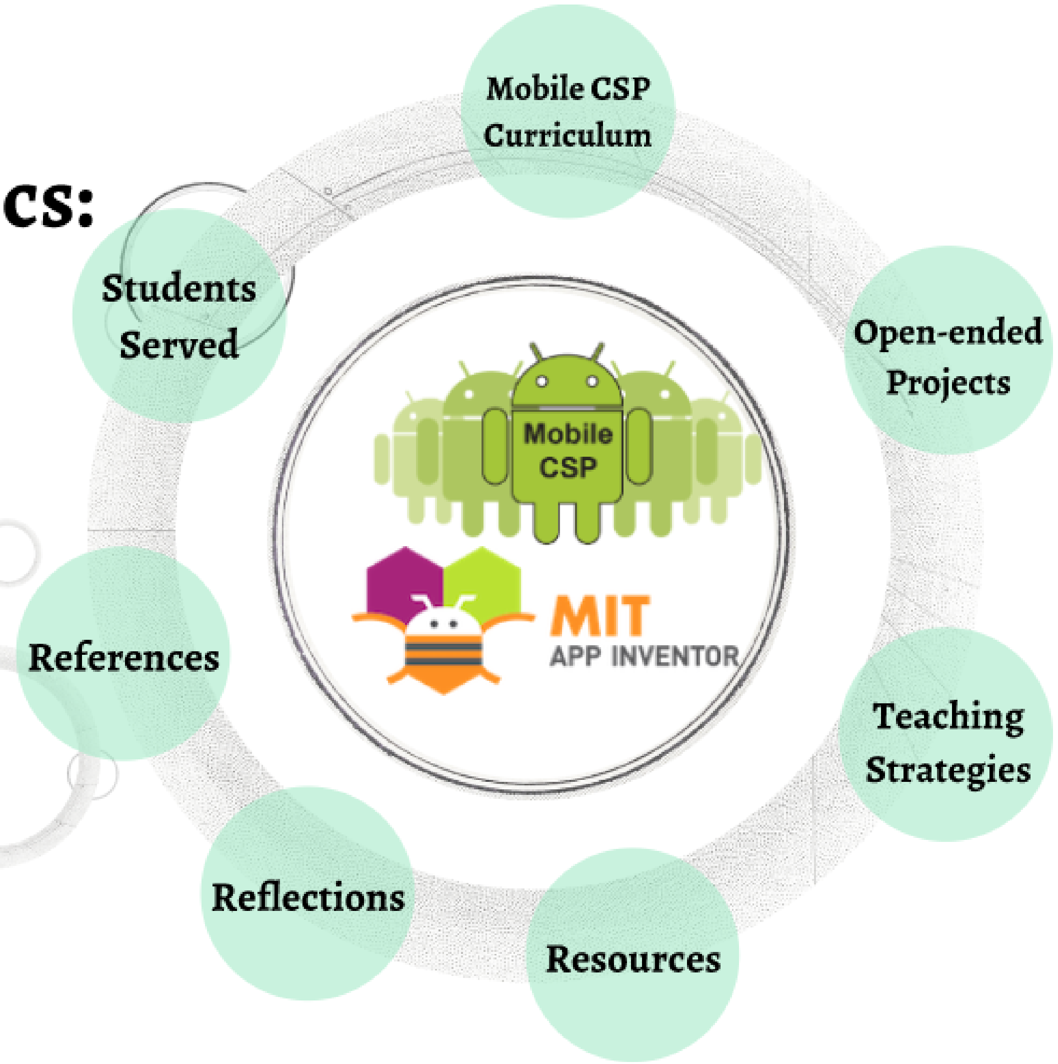

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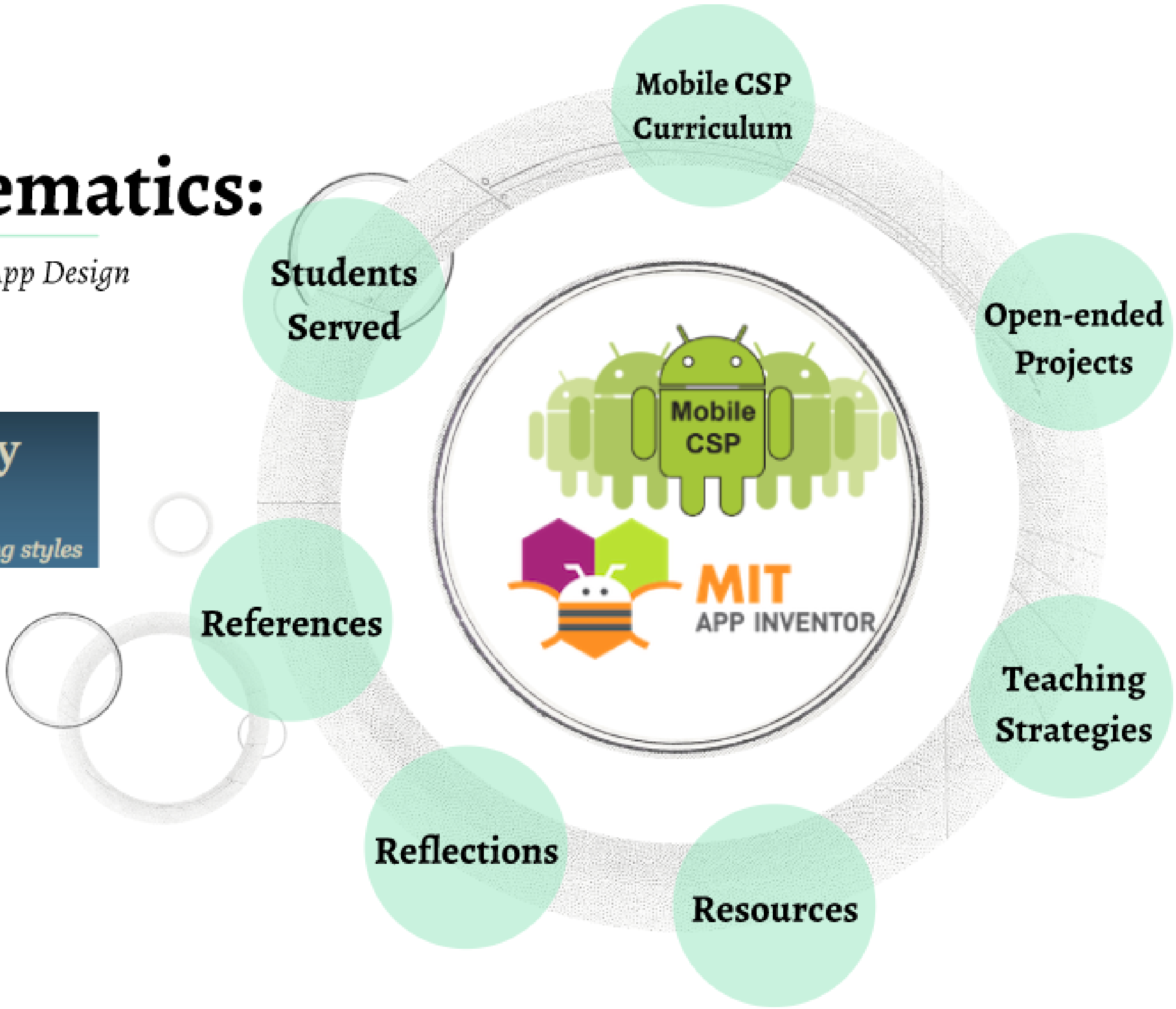

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