# Automated measures of student elegance

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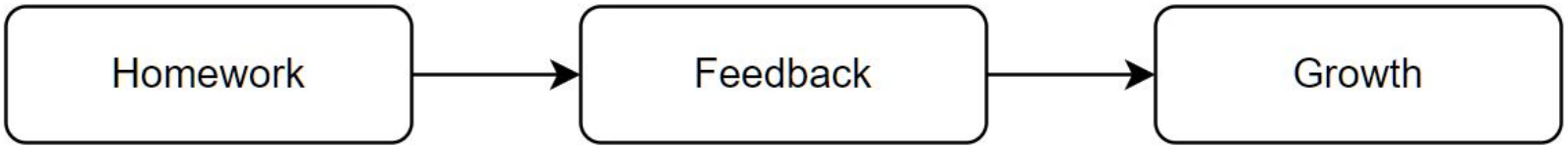
# Before we start…

- This is an ongoing project
- We’d love to hear your feedback and ideas on our work so far

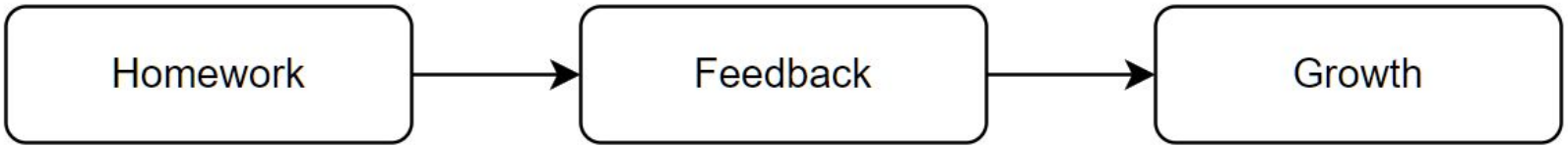
# Background

- Students need feedback on their formative assignments
- We'd like to give feedback by hand



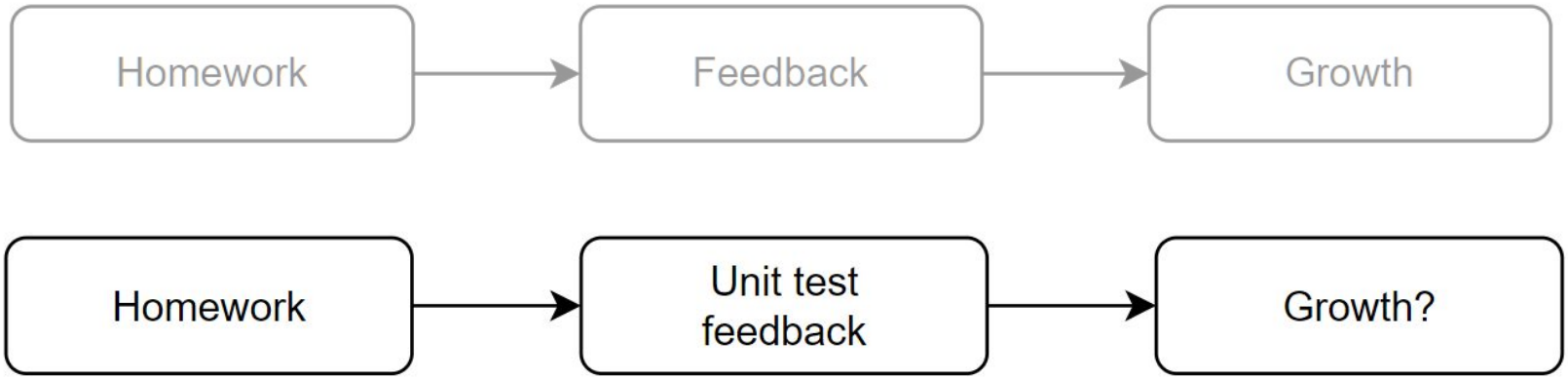
# The problem

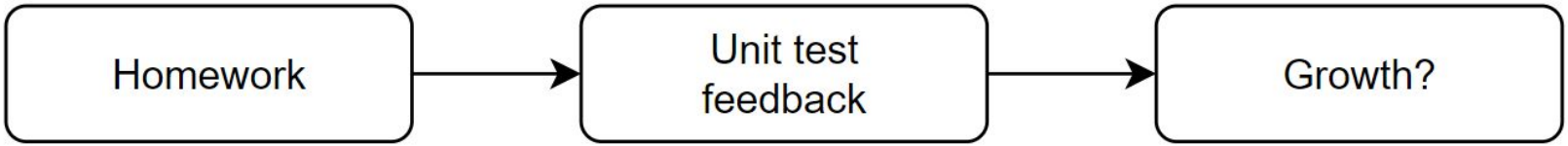
- Computer science educators aren’t grading essays
- Lots of students and many assignments makes grading by hand infeasible

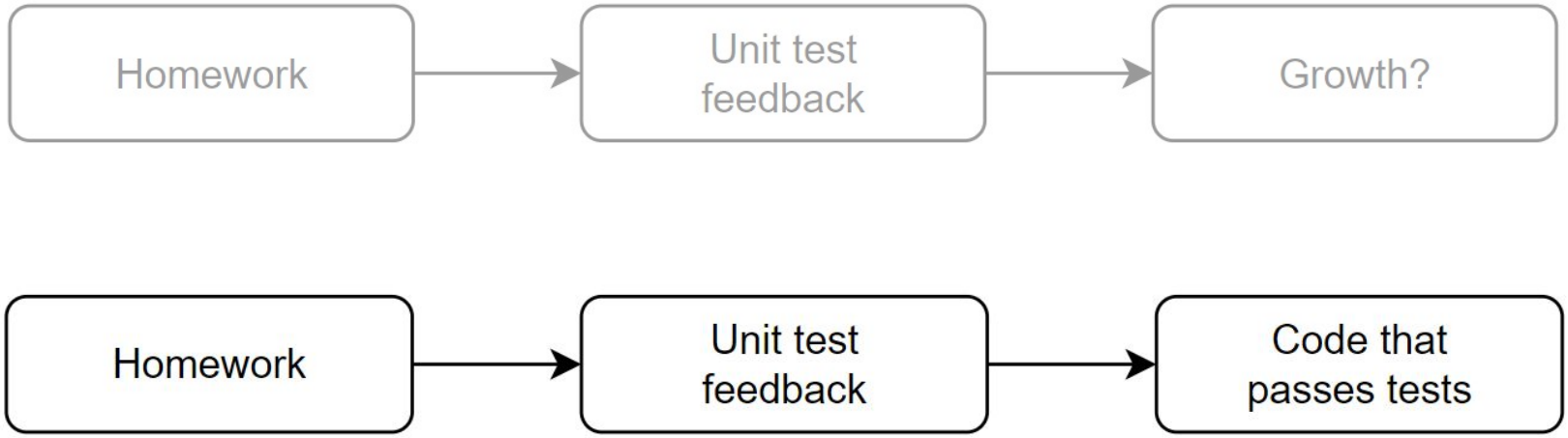


# Enter unit tests

- We use automation to give students instant feedback
- Students see whether their code passes unit tests on demand




Homework
Unit test feedback
Growth?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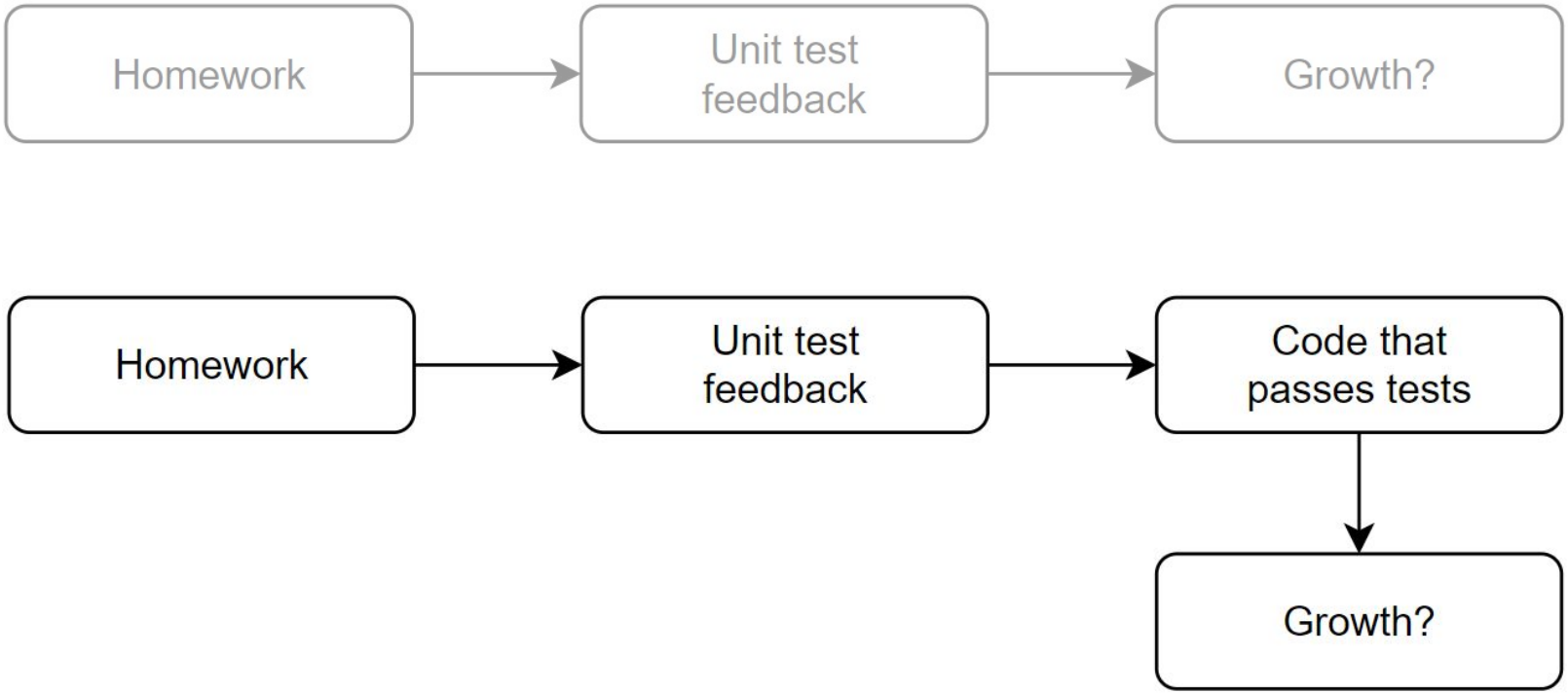
Code that passes tests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# More than correctness

- Passing unit tests is important, but professional software developers aim to write code that is:
  - Maintainable
  - Efficient
  - Readable
  - Secure
- Can basic unit tests encourage this?

# An example: mostCommonCharacter

- An exercise to teach Map objects for our second course in computer science

- Given a string, find the most common character

- Our expected solution: iteration over the string, updating a map

    - Example: on input “banana”, the built map would be {(‘n’,2),(‘b’,1),(‘a’,3)}.

# An example: mostCommonCharacter

- A solution from a real student

```
public static char mostCommonCharacter38(String input) {
    int[] alpha = new int[26];
    for(int i = 0; i < input.length(); i++) {
        if(input.charAt(i) == 'a') alpha[0]++;
        if(input.charAt(i) == 'b') alpha[1]++;
        if(input.charAt(i) == 'c') alpha[2]++;
        if(input.charAt(i) == 'd') alpha[3]++;
        if(input.charAt(i) == 'e') alpha[4]++;
        if(input.charAt(i) == 'f') alpha[5]++;
        if(input.charAt(i) == 'g') alpha[6]++;
        if(input.charAt(i) == 'h') alpha[7]++;
        if(input.charAt(i) == 'i') alpha[8]++;
        if(input.charAt(i) == 'j') alpha[9]++;
        if(input.charAt(i) == 'k') alpha[10]++;
        if(input.charAt(i) == 'l') alpha[11]++;
        if(input.charAt(i) == 'm') alpha[12]++;
        if(input.charAt(i) == 'n') alpha[13]++;
        if(input.charAt(i) == 'o') alpha[14]++;
        if(input.charAt(i) == 'p') alpha[15]++;
        if(input.charAt(i) == 'w') alpha[22]++;
        if(input.charAt(i) == 'x') alpha[23]++;
        if(input.charAt(i) == 'y') alpha[24]++;
        if(input.charAt(i) == 'z') alpha[25]++;
    }
    int largest = 0;
    int numberAlpha = 0;
    for(int i = 0; i < alpha.length; i++) {
        if(alpha[i] > largest) {
            largest = alpha[i];
            numberAlpha = i;
        }
    }
```

# Our metric: Elegance

- There’s no standard definition of “elegance” in coding
- We do agree that unnecessary code is inelegant
  - Extra for loop
  - Useless variable
  - Redundant if statement

# Why do we care about inelegance?

- Encouraging student to limit their “if” and “for” statements pushes them to learn about the language they’re working in, or to reuse code they’ve already written
  - Example: Java’s getOrDefault for Maps
- Students might reflect on the code they write instead of chasing after correctness
  - Discourages guess-and-check strategies while coding
- Prepares students for environments where code needs to be more than functional

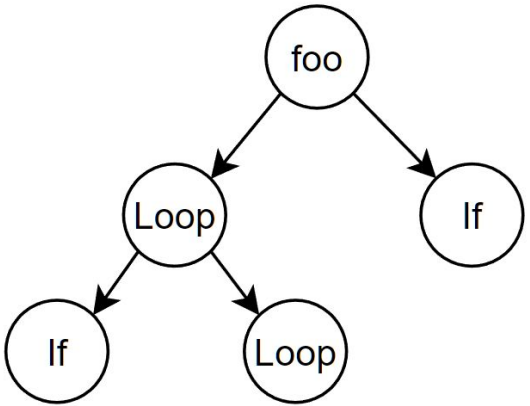
# How can we measure inelegance?

- Linting tools: mostly meant for professional software developers
- AI: not trustworthy or explainable

# Measuring inelegance

```
private int foo(int arg) {
    for (...) {
        if (...) {
            ...
        }
        while (...) {
            ...
        }
    }
    if (...) {
        ...
    } else {
        ...
    }
}
```

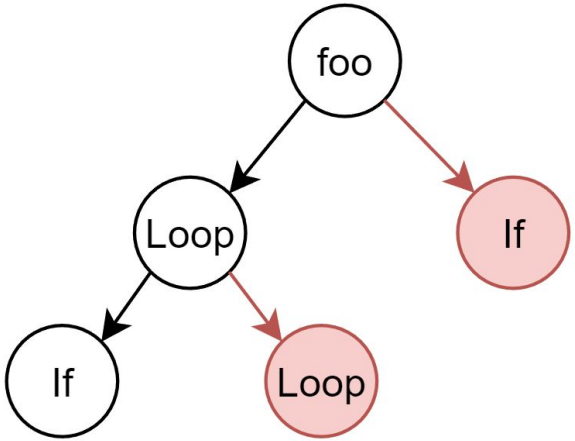
- We use a parser to generate an Abstract Syntax Tree (AST) for a student's code
- We use that to generate a tree of our own for each function
  - We record loops (for, while) and selection statements (if/else, ternary operator)



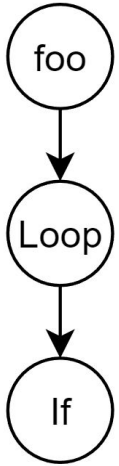
# Measuring inelegance

- The instructor writes an intended solution to each method
- We compare the student's tree against the instructor's intended solution tree, and count the extra statements

Student solution




Intended solution



# Examples

Unnecessary base case

```java
public static int firstDivisibleBy7752(int[] numbers) {
    if (numbers.length == 0) {
        return -1;
    }

    for (int i = 0; i < numbers.length; i++) {
        if (numbers[i] % 77 ==0) {
            return numbers[i];
        }
    }
    return -1;
}
```

Could have used substring

```java
public static ArrayList<String> threeCharacterStrings60(String input) {
    ArrayList<String> list = new ArrayList<>();
    if(input.length()  == 3) {
        list.add(input);
        return list;
    }else if(input.length()/3 < 1) {
        return list;

    }else {
        for(int i =0; i < input.length() - 2 ; i++) {
            String part = "";
            char a = input.charAt(i);
            char b = input.charAt(i+1);
            char c = input.charAt(i+2);
            String end = part+ a + b +c;
            list.add(end);
        }
    }
    return list;
}
```

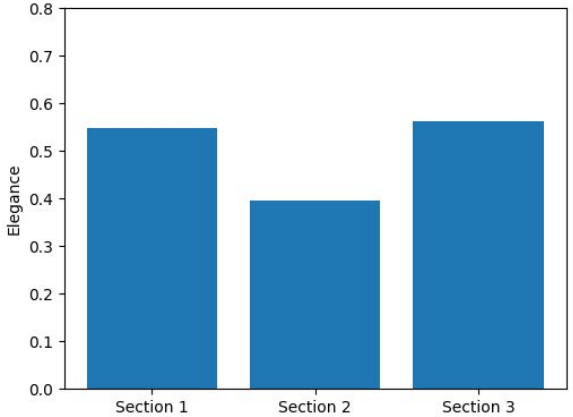
# Experiment

- We had 3 sections of students taking our object-oriented Java course
- On their Maps homework assignment, we issued section 2 a challenge; sections 1 and 3 were not treated
- We challenged section 2 to implement mostCommonCharacter with at most 12 lines of code, 1 for loop, and 1 if statement
- This required keeping a running maximum (as opposed to first building a map, and then iterating through the map) and using getOrDefault

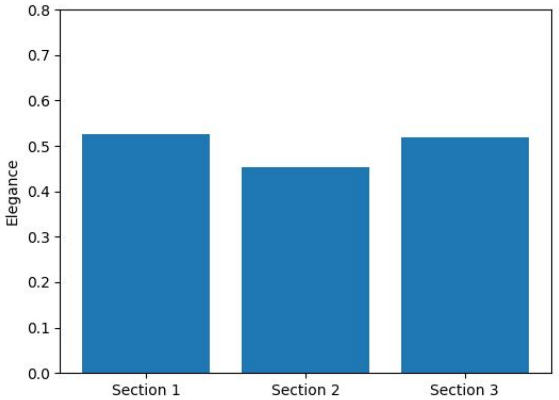
# Results

- On the methods they weren't challenged on, section 2 was less elegant
- Section 2 improved on the challenged method, but the results weren't spectacular

Other four methods




Challenged method



# Next Steps

Challenge Experiment

- We want to repeat the challenge experiment again
- The first time, the challenge was administered in class, with nothing in the starter file provided to the students
- During a repeat we would like to include comments in the starter code file that reinforces the challenge and provides the details of X lines of code,Y ‘for’/’while’ loops, and Z ‘if’ statements

Tool Support

- Create an IDE plugin that analyzes an operation for elegance
- This plugin would provide elegance feedback to the student during the development phase
- This evaluation would be based on a comparison of the students code versus the instructor’s intended solution