Teaching Composition Quality at Scale

Human Judgment in the Age of Autograders

John DeNero & Stephen Martinis

Google & Berkeley UNIVERSITY OF CALIFORNIA

Computer Science Courses are Growing

Photos by Brian Ly, Daily Cal Staff

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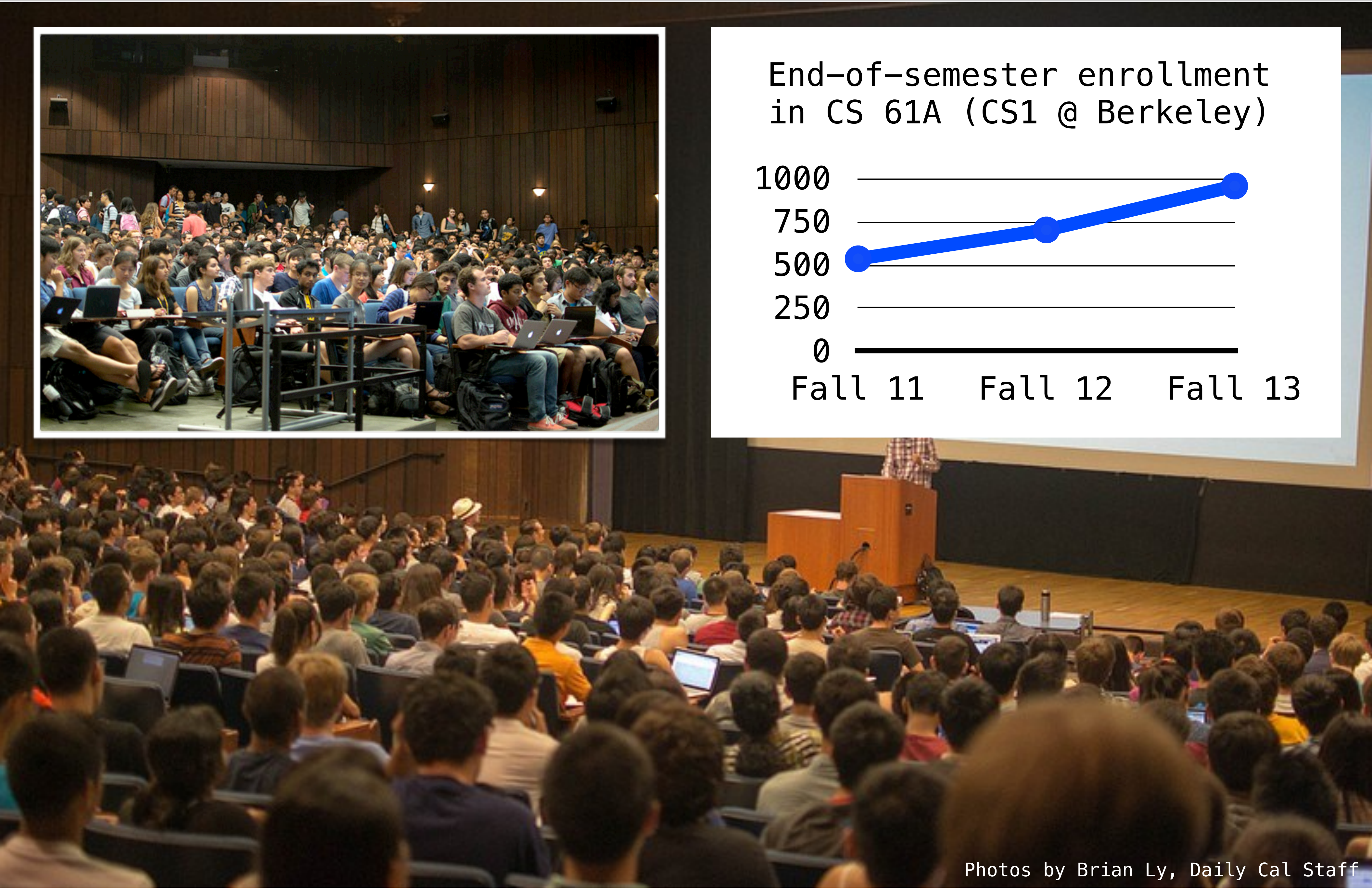

End-of-semester enrollment in CS 61A (CS1 @ Berkeley)

Photos by Brian Ly, Daily Cal Staff

Teaching Composition Quality

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and only incidentally for machines to execute."
— Structure and Interpretation of Computer Programs

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Correctness

Composition

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	Who?
Correctness	Computer
Composition	Humans

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	Who?	**How?**
Correctness	Computer	Script
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	Who?	**How?**	**Why?**
Correctness	Computer	Script	78/90
Composition	Humans	Code Reviews	12/90

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	Who?	**How?**	**Why?**	**When?**
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Composition	Humans	Code Reviews	12/90	~2 weeks

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Guidelines & Useful Examples

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- Many composition issues only arise in programs of sufficient complexity.
- *Our solution*: Emphasize composition in projects.

Focus on Human Judgment

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Code Style

Rules of Thumb

Effective Communication

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Code Style	**Rules of Thumb**	**Effective Communication**

`sum_of(x, y)`
vs
`SumOf(x,y)`
	A function body should have at most k lines.	*Why is each variable name introduced?*

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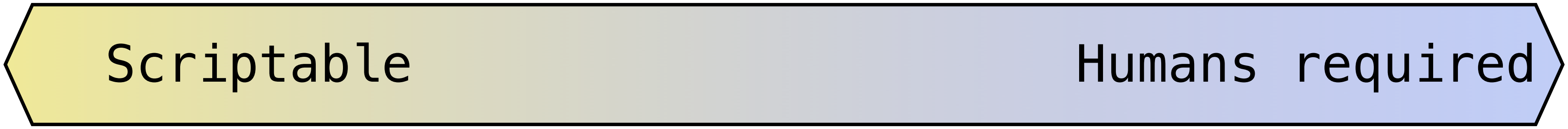
Scriptable

Humans required

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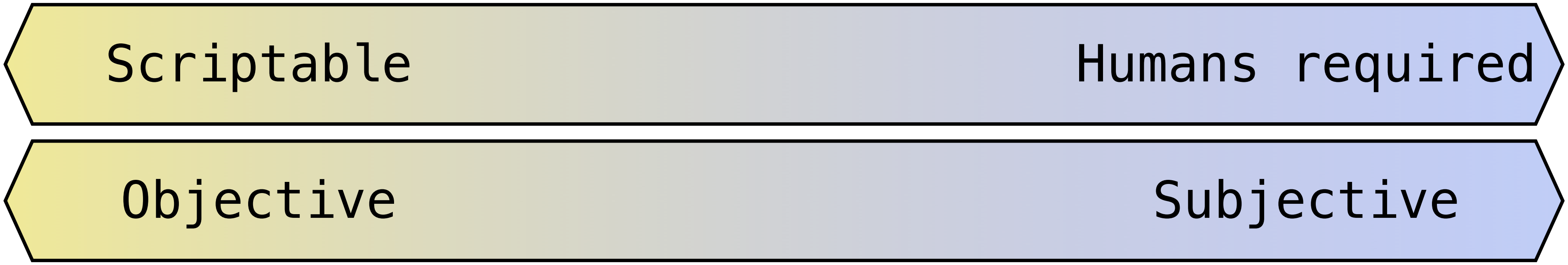

Scriptable — Humans required

Objective — Subjective

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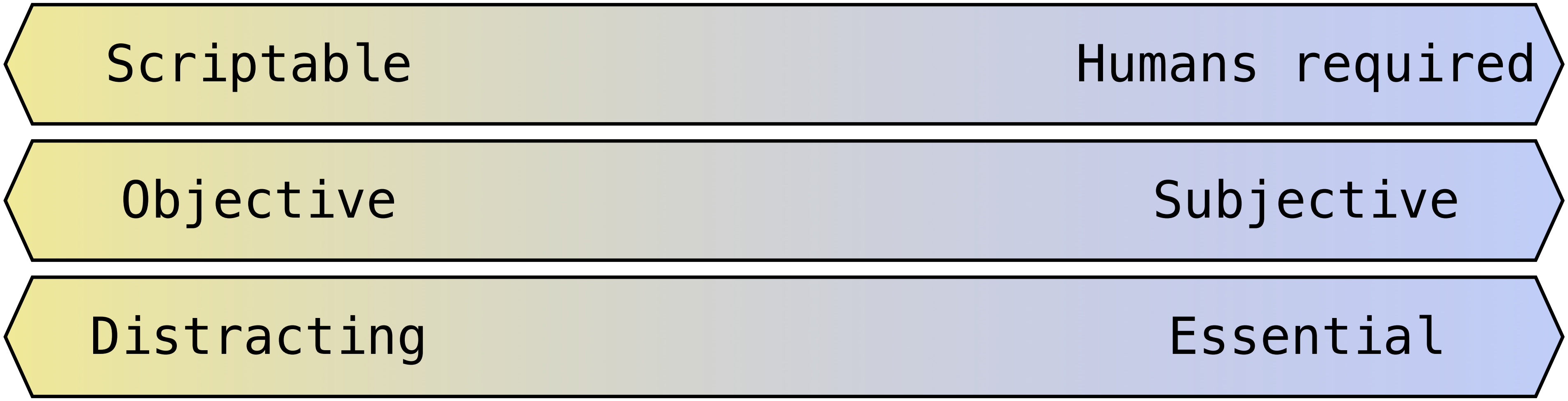

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Purpose Remove all unused and unnecessary code and comments, leaving behind only code with a purpose.

Brevity Prefer concise implementations to convoluted ones, without explicitly minimizing the line count.

Scaffolded Programming Projects

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Fill-in-the-blank starter code and a full test suite

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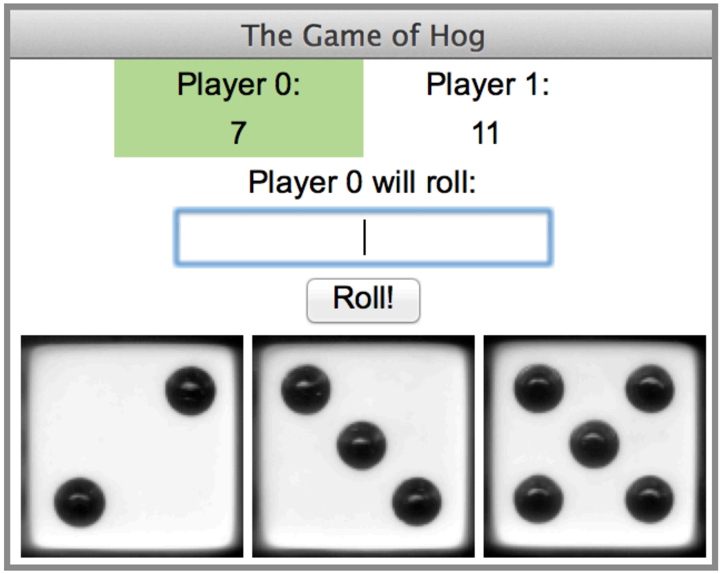

The "Hog" project is based on Todd Neller's "Pig" project, Nifty Assignments 2010.

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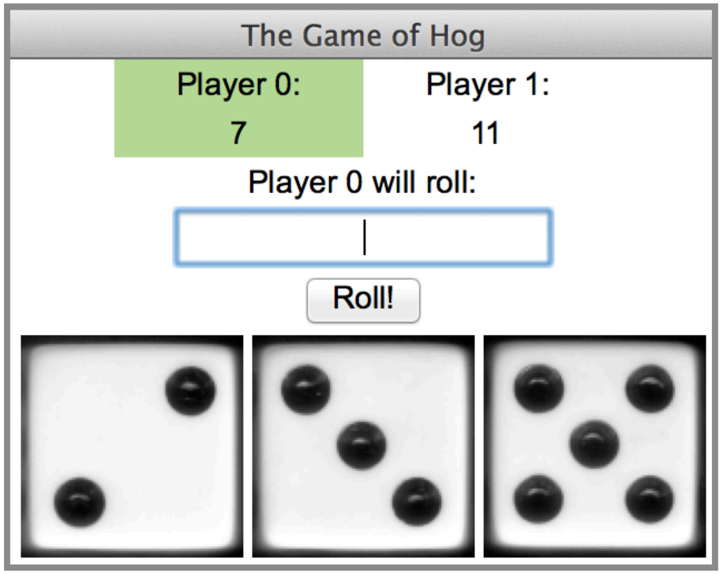
Composition can be taught by example in context.



The Game of Hog

Player 0: 7

Player 1: 11

Player 0 will roll:

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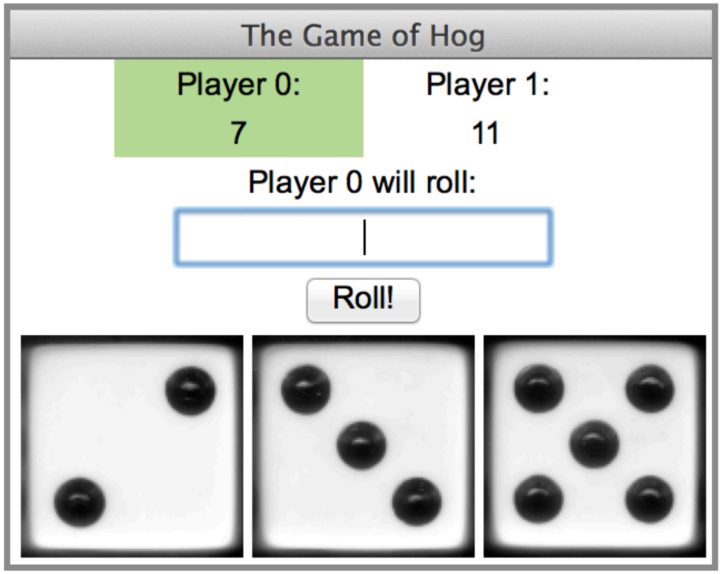

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Player 0: 7

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```
def make_averaged(fn, num_samples=1000):
    """Return a function that returns the average
    return value of FN called NUM_SAMPLES times.

    >>> dice = make_test_dice(3, 1, 5, 6)
    >>> averaged_dice = make_averaged(dice, 1000)
    >>> averaged_dice()
    3.75
    """
    "*** YOUR CODE HERE ***"
```

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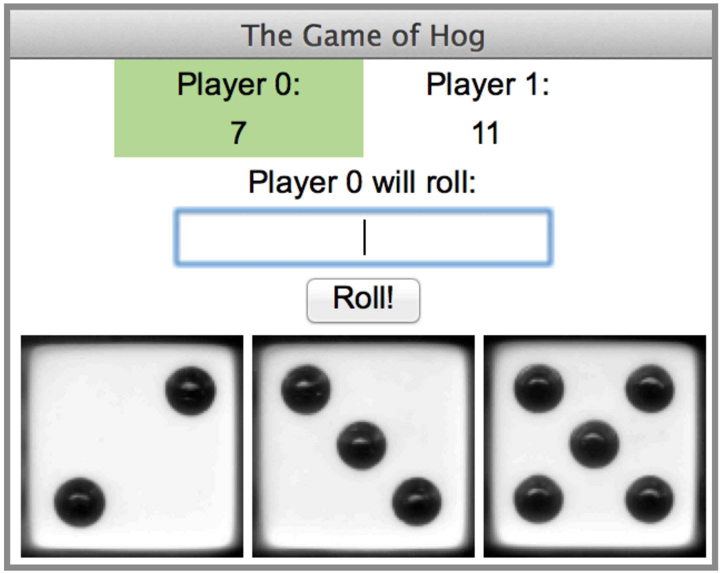

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Shameless advertisement: All four course projects are freely available with comprehensive autograders.

(See one in the Nifty Assignments session tomorrow.)

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Online Composition Feedback System

Previous Work

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Previous Work

```
def find_centroid(polygon):
    def get_x(p):
        return latitude(p)
    def get_y(p):
        return longitude(p)
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```
    fsum = 0;
    def f( p1,p2):
        return get_x(p1)∗get_y(p2)−get_x(p2)∗get_y(p1)
    area = ...
    if(area == 0):
        return (latitude(polygon[0]),longitude(polygon[0]),0)
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To give a new name to a function, you can use assignment:
get_y = longitude

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    fsum = 0;
    def f( p1,p2):
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polygon[0] is repeated; perhaps give it the name "first" instead.
```

Previous Work

Nice work. Keep looking for more ways to eliminate repeated expressions by introducing names.

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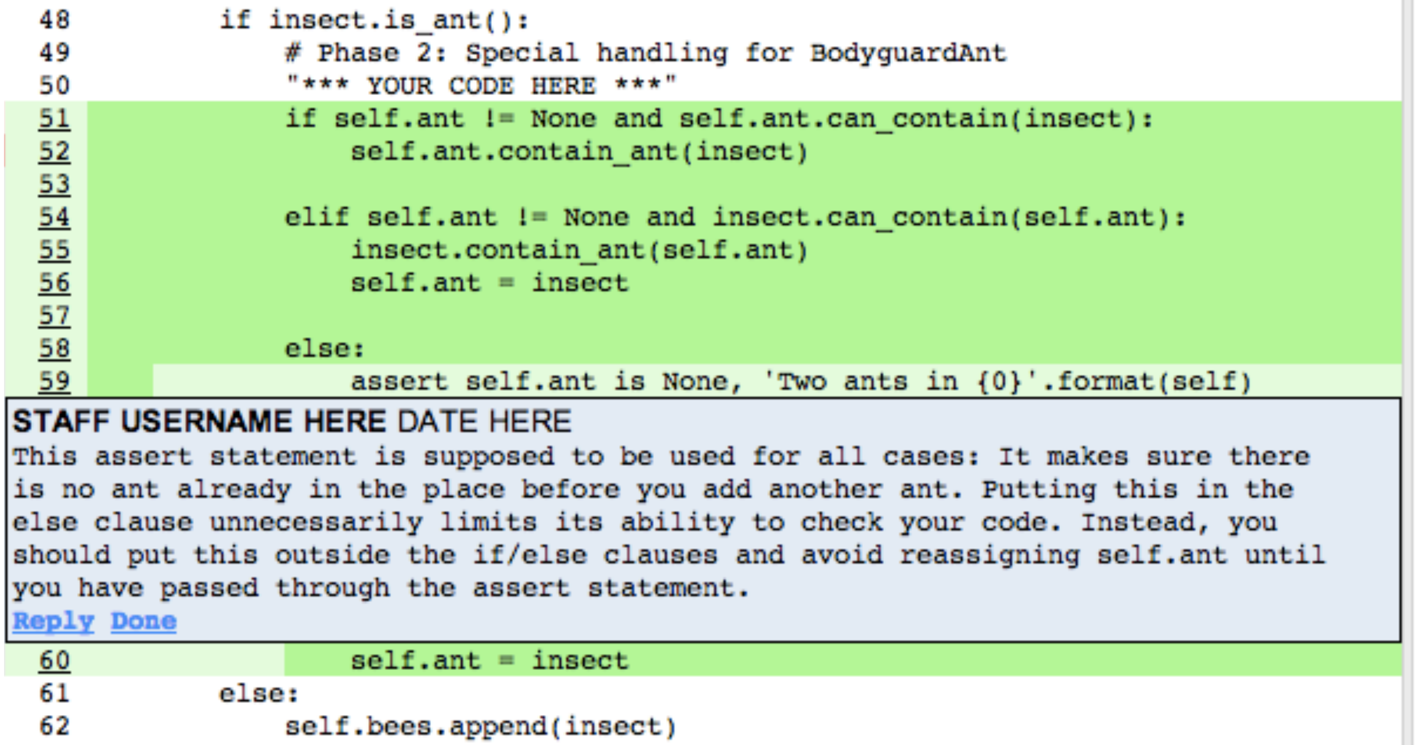

```
        if insect.is_ant():
            # Phase 2: Special handling for BodyguardAnt
            "*** YOUR CODE HERE ***"
            if self.ant != None and self.ant.can_contain(insect):
                self.ant.contain_ant(insect)

            elif self.ant != None and insect.can_contain(self.ant):
                insect.contain_ant(self.ant)
                self.ant = insect

            else:
                assert self.ant is None, 'Two ants in {0}'.format(self)
```

STAFF USERNAME HERE DATE HERE

This assert statement is supposed to be used for all cases: It makes sure there is no ant already in the place before you add another ant. Putting this in the else clause unnecessarily limits its ability to check your code. Instead, you should put this outside the if/else clauses and avoid reassigning self.ant until you have passed through the assert statement.

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                self.ant = insect
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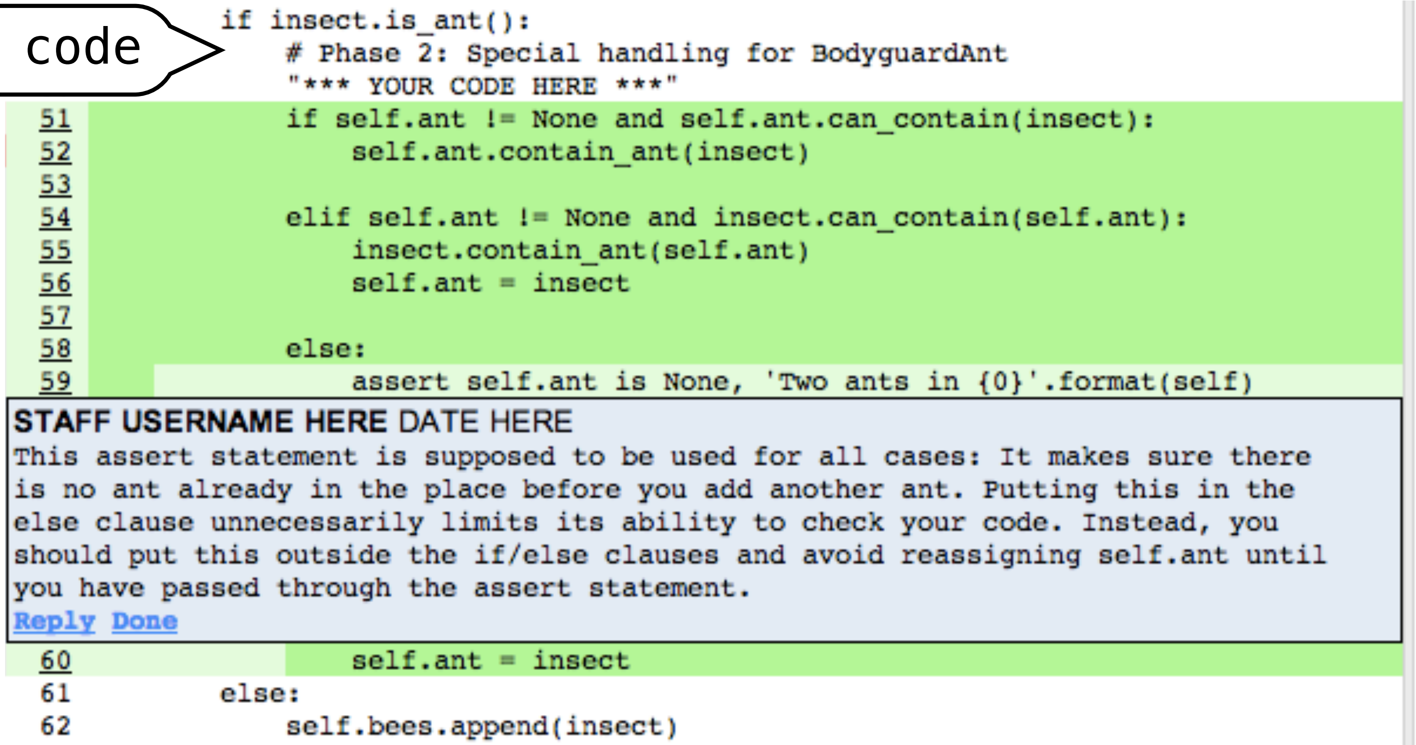
Starter code



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if insect.is_ant():
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Reply Done

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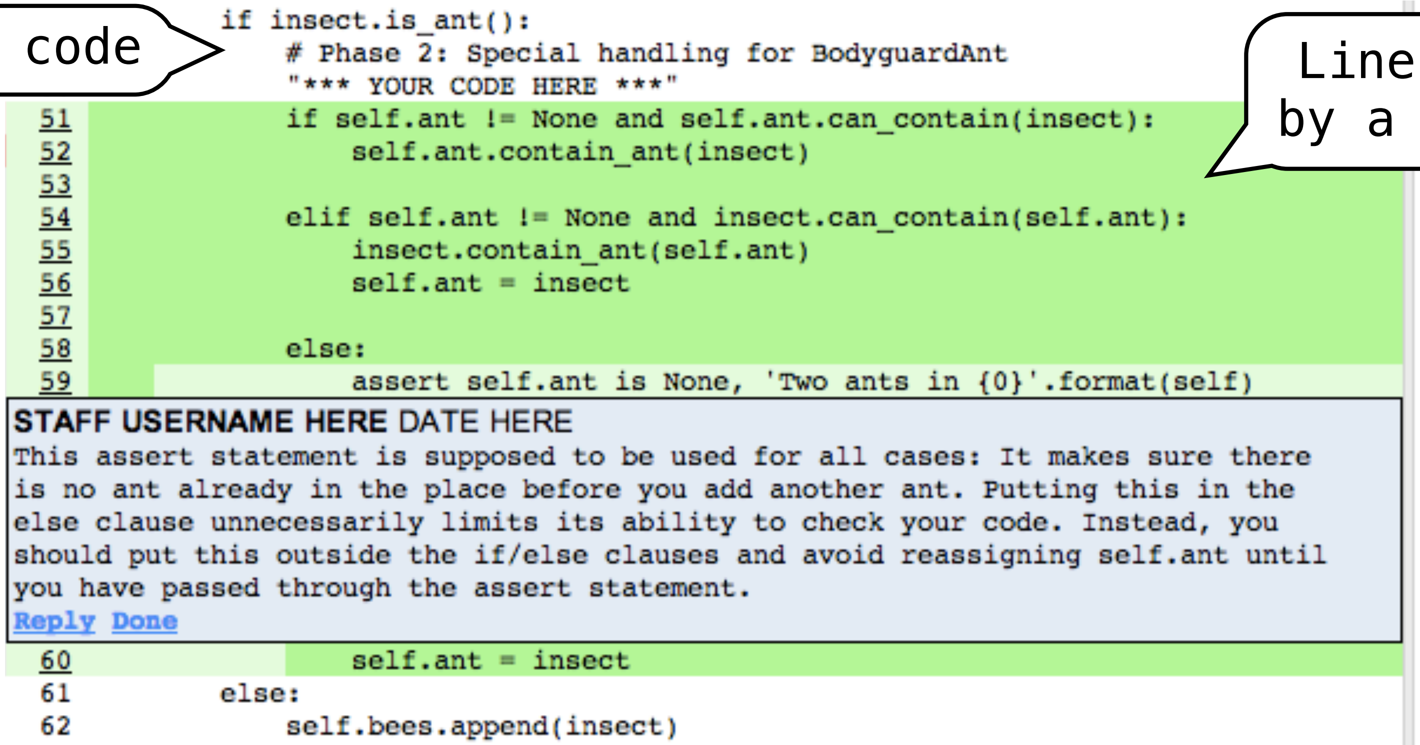

Starter code

Lines added by a student

```
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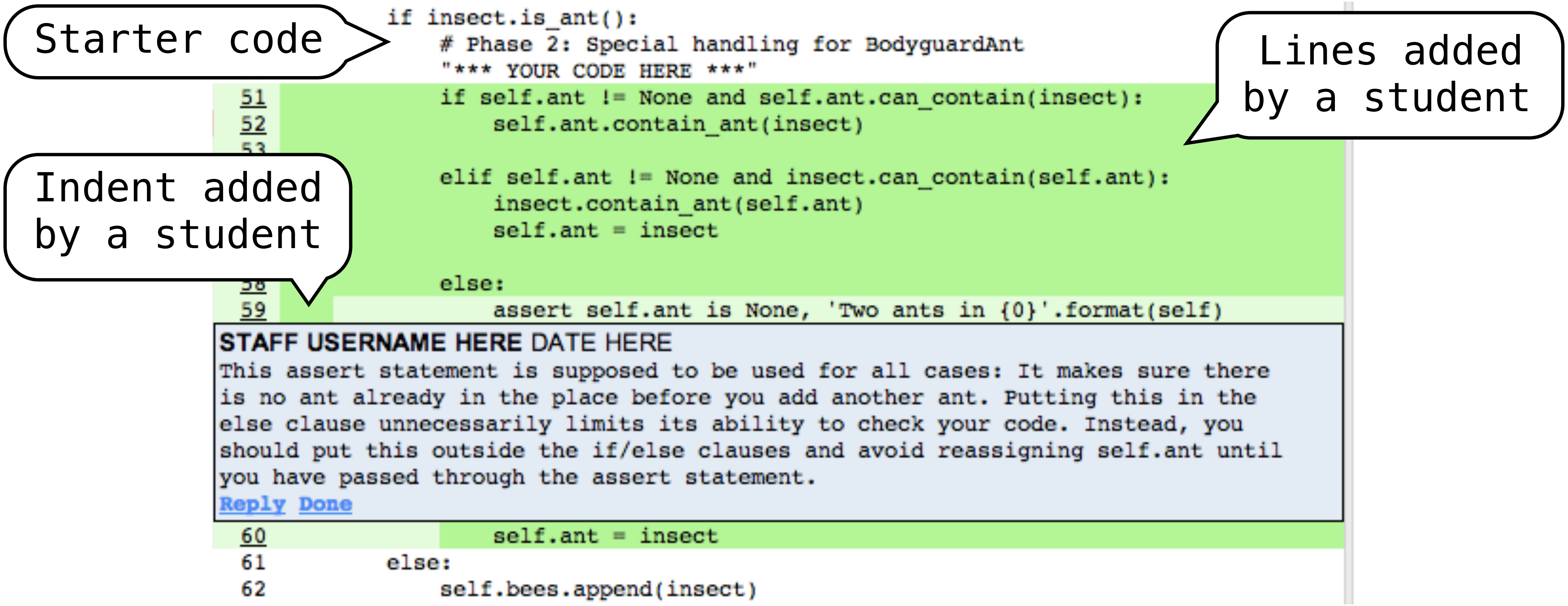

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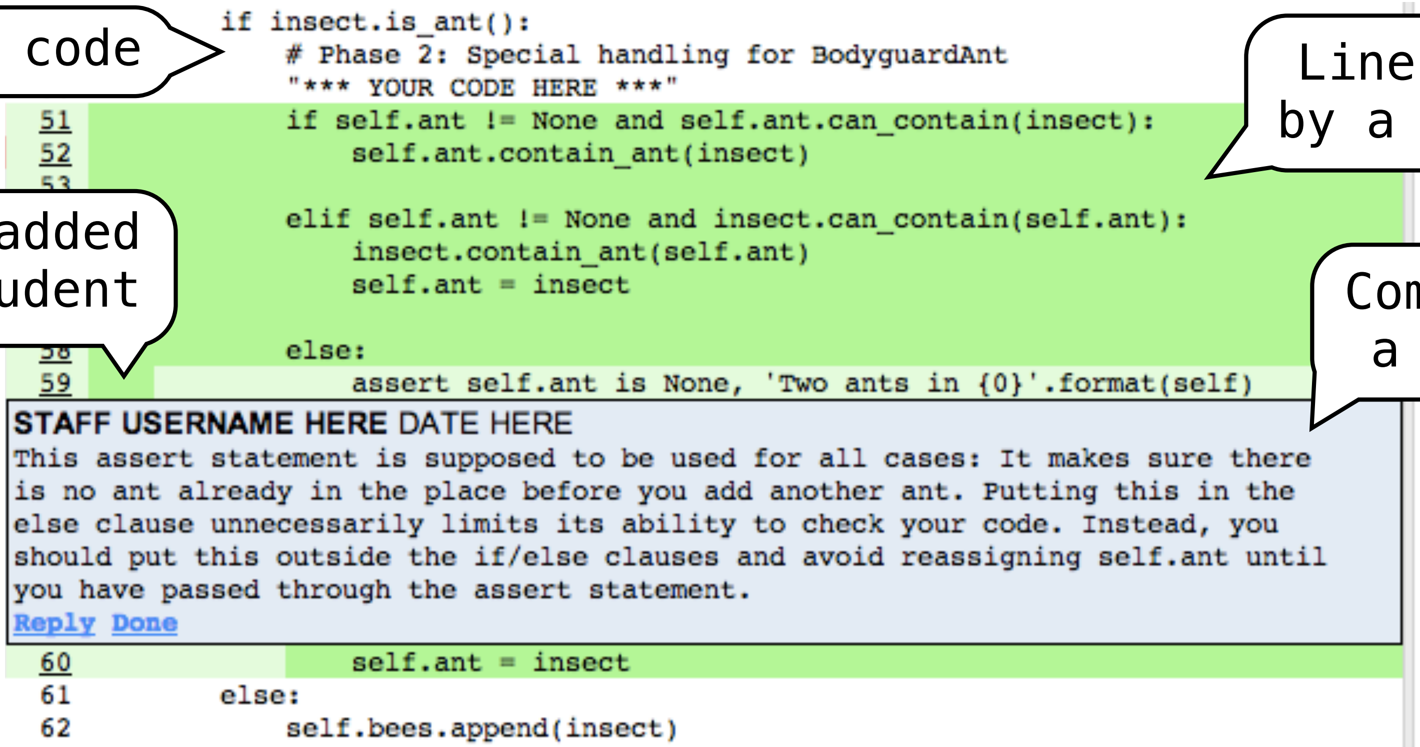

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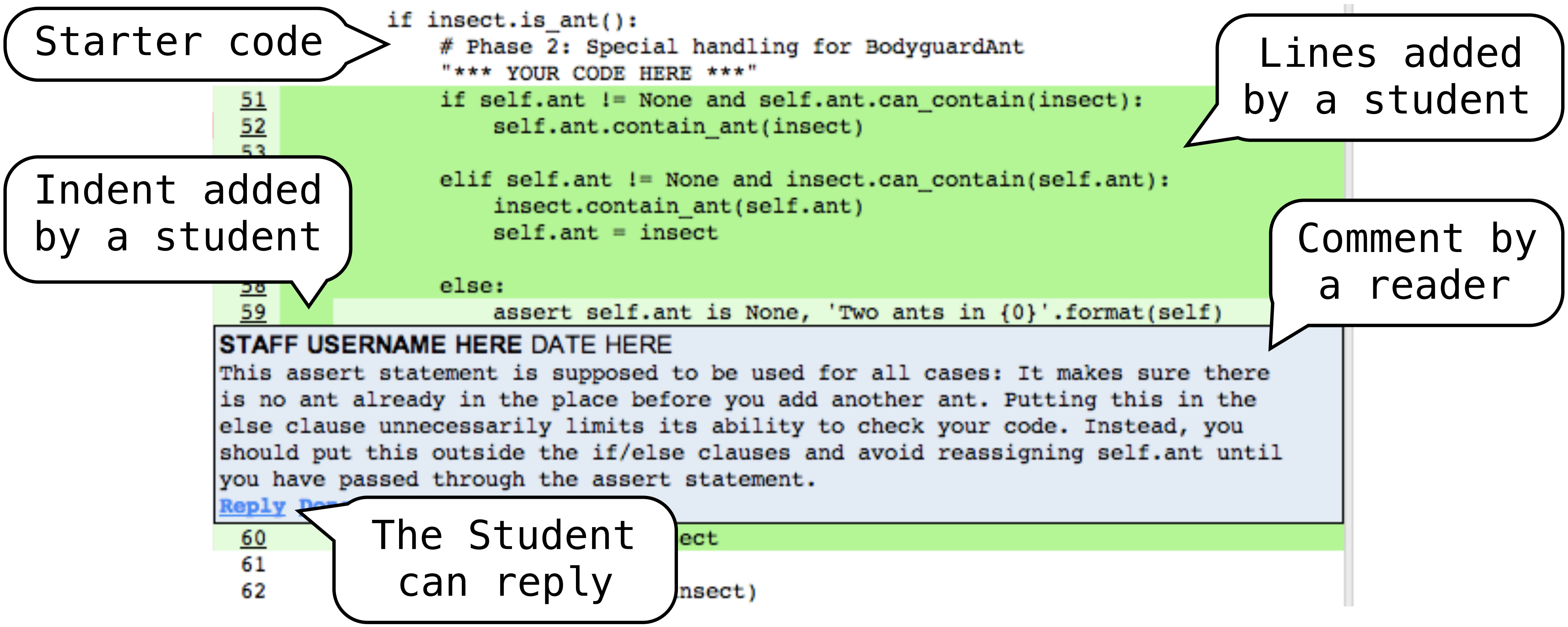

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The Student can reply

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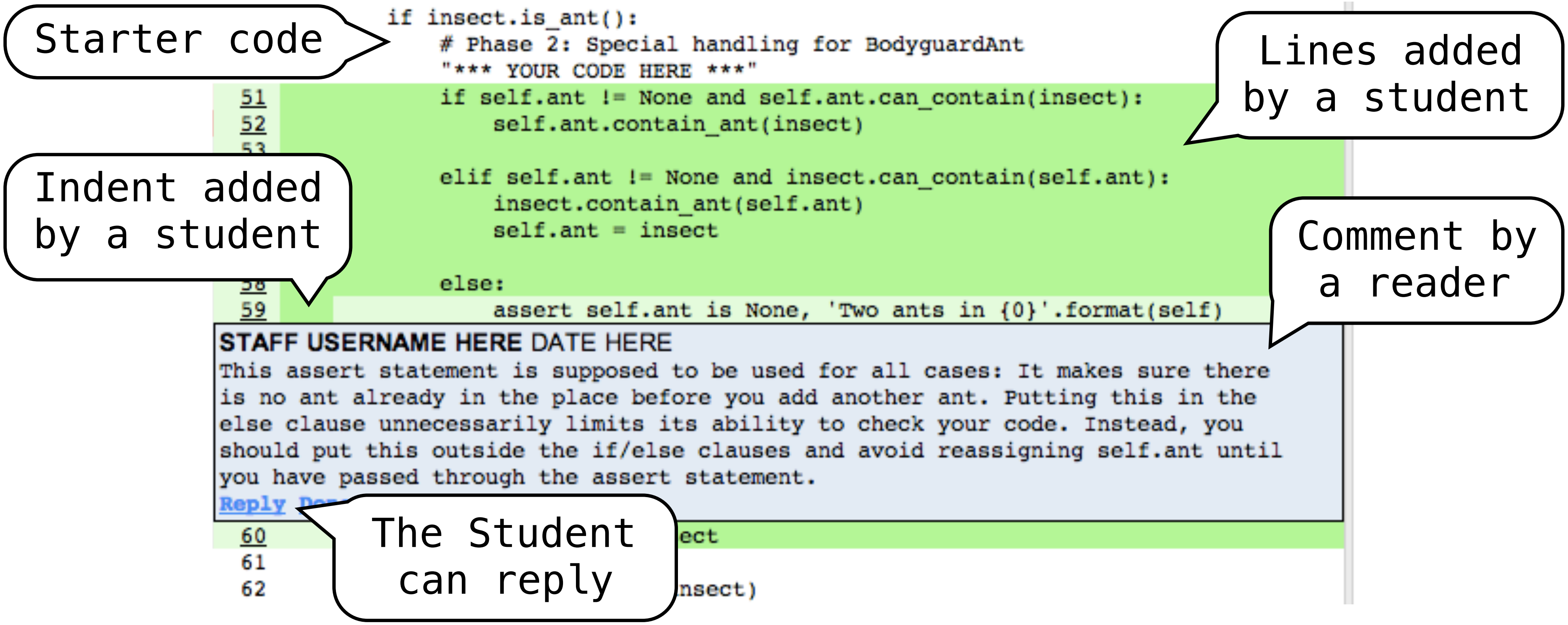

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- Shared cache of comments among all graders.

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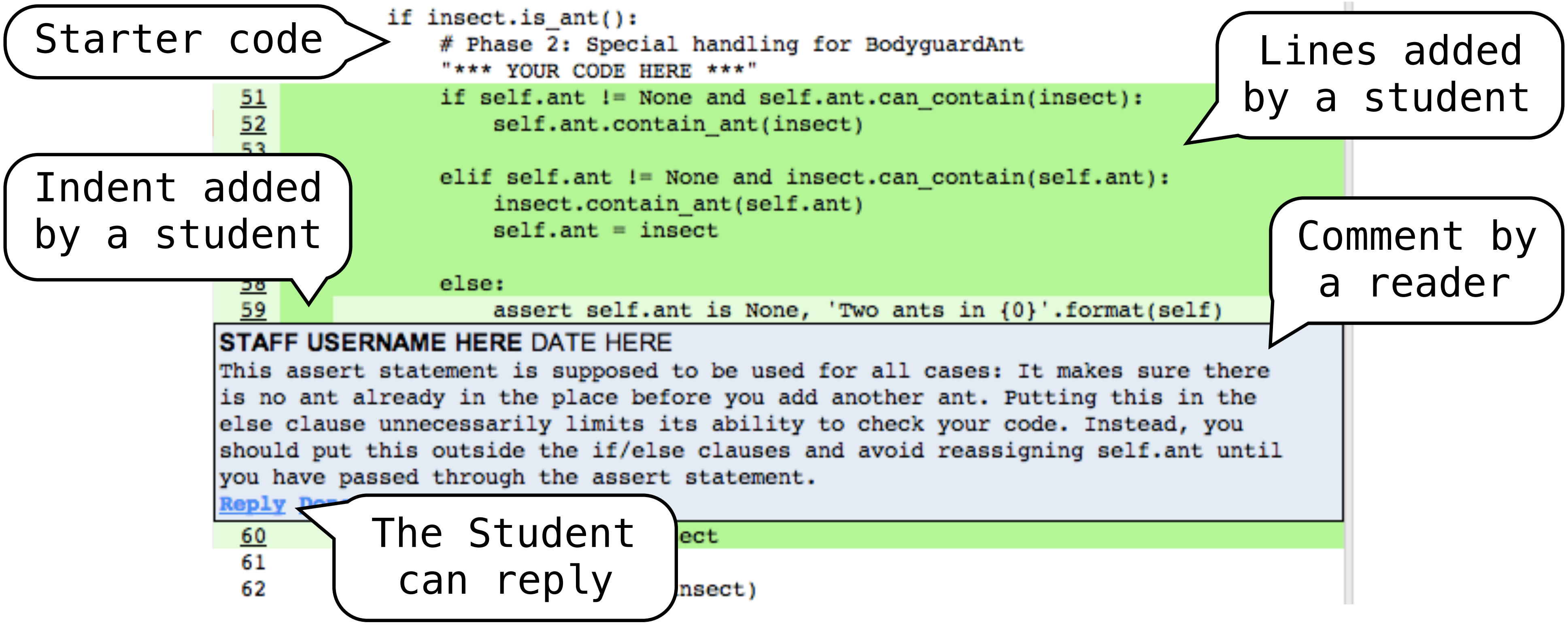

Starter code

Lines added by a student

Indent added by a student

Comment by a reader

The Student can reply

```
if insect.is_ant():
    # Phase 2: Special handling for BodyguardAnt
    "*** YOUR CODE HERE ***"
    if self.ant != None and self.ant.can_contain(insect):
        self.ant.contain_ant(insect)

    elif self.ant != None and insect.can_contain(self.ant):
        insect.contain_ant(self.ant)
        self.ant = insect

    else:
        assert self.ant is None, 'Two ants in {0}'.format(self)
```

STAFF USERNAME HERE DATE HERE

This assert statement is supposed to be used for all cases: It makes sure there is no ant already in the place before you add another ant. Putting this in the else clause unnecessarily limits its ability to check your code. Instead, you should put this outside the if/else clauses and avoid reassigning self.ant until you have passed through the assert statement.

Reply

```
                                  ect

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- Shared cache of comments among all graders.
- Integration with existing version control systems.

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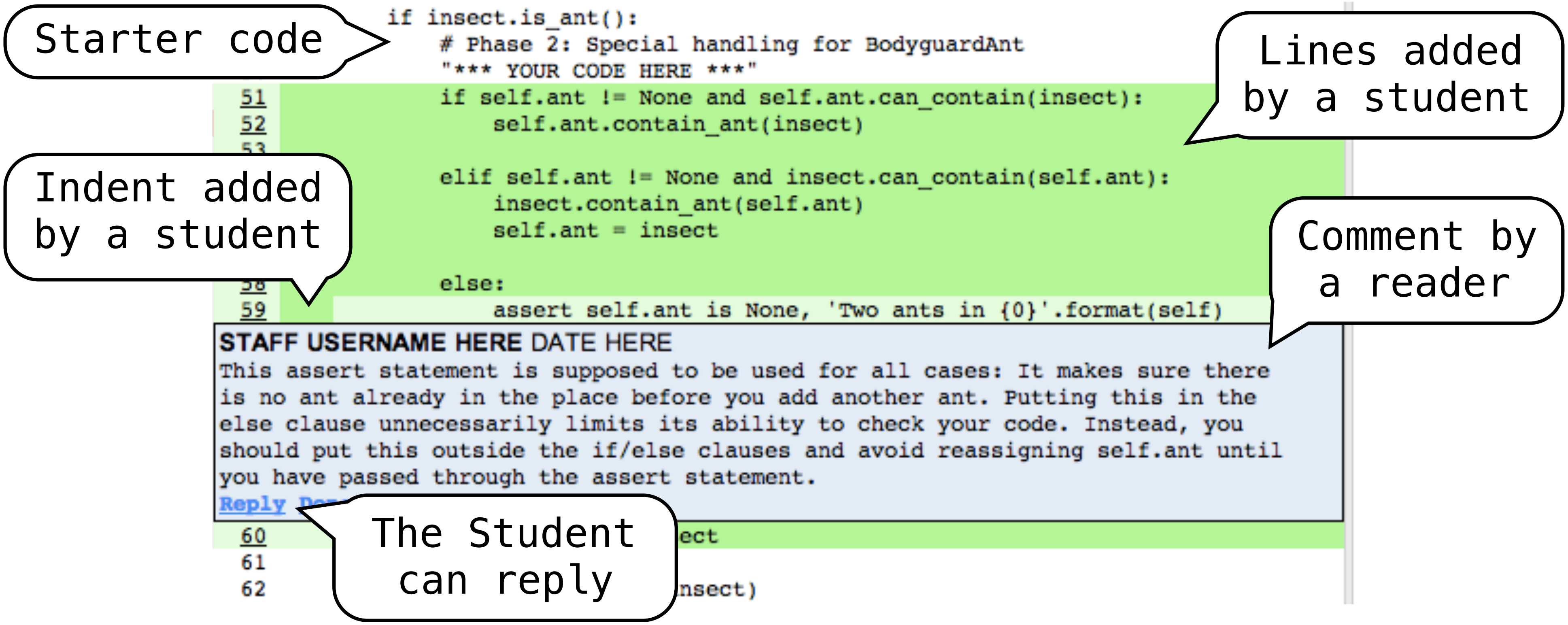

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- Shared cache of comments among all graders.
- Integration with existing version control systems.
- Easy administration through Google App Engine.

Evaluations

End-of-Semester Survey Results

Fall 2012 Average of 626 Responses
(All questions rated on a scale from 1 to 5)

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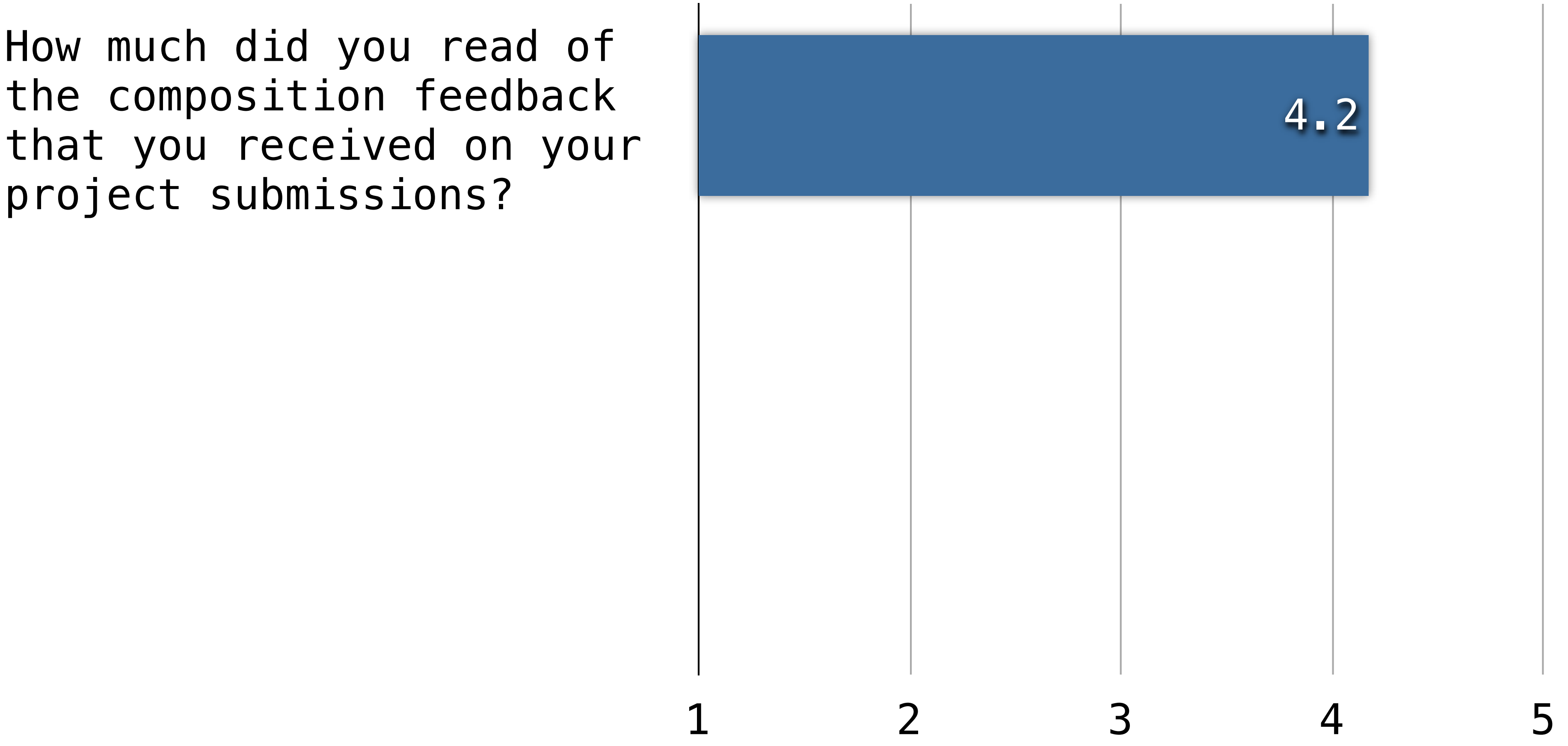

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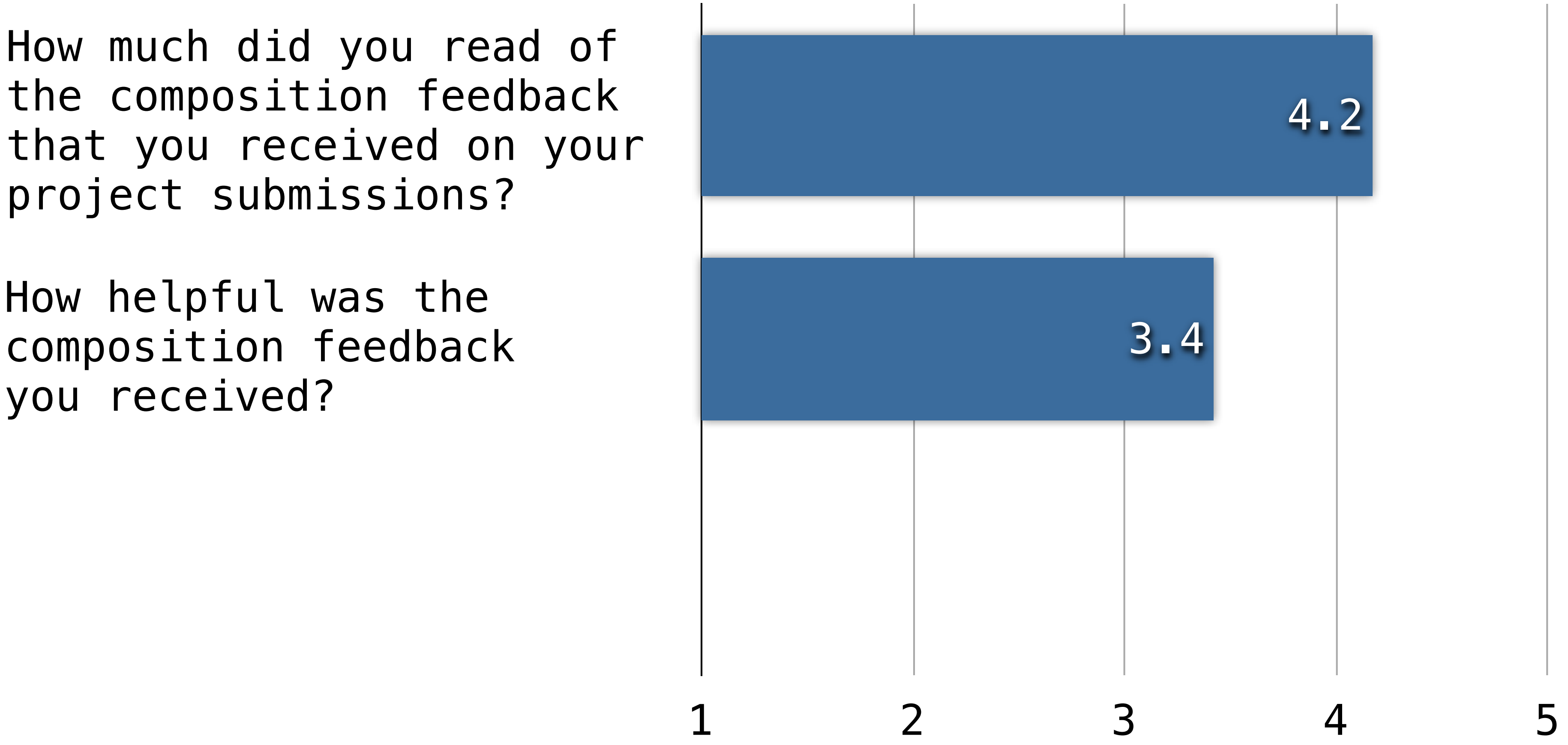

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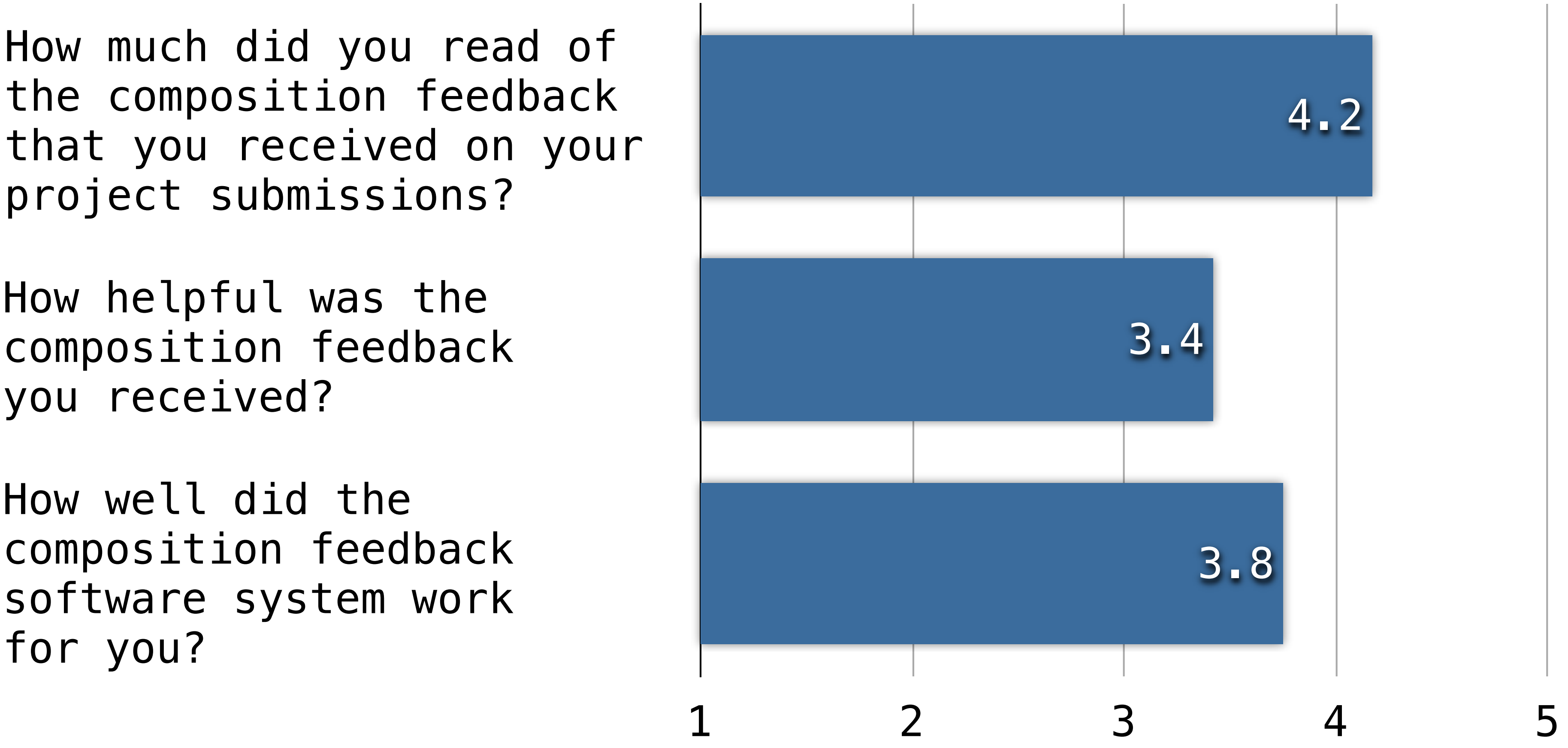

Blind Comparison of Student Submissions

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Experiment Design

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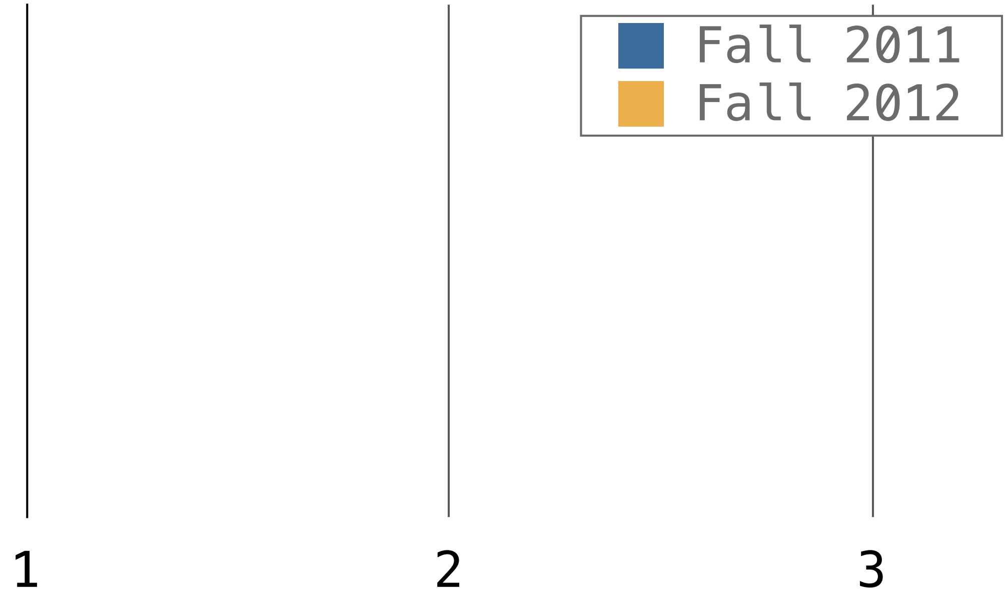
Average Responses by Graders (Scale from 1 to 3)



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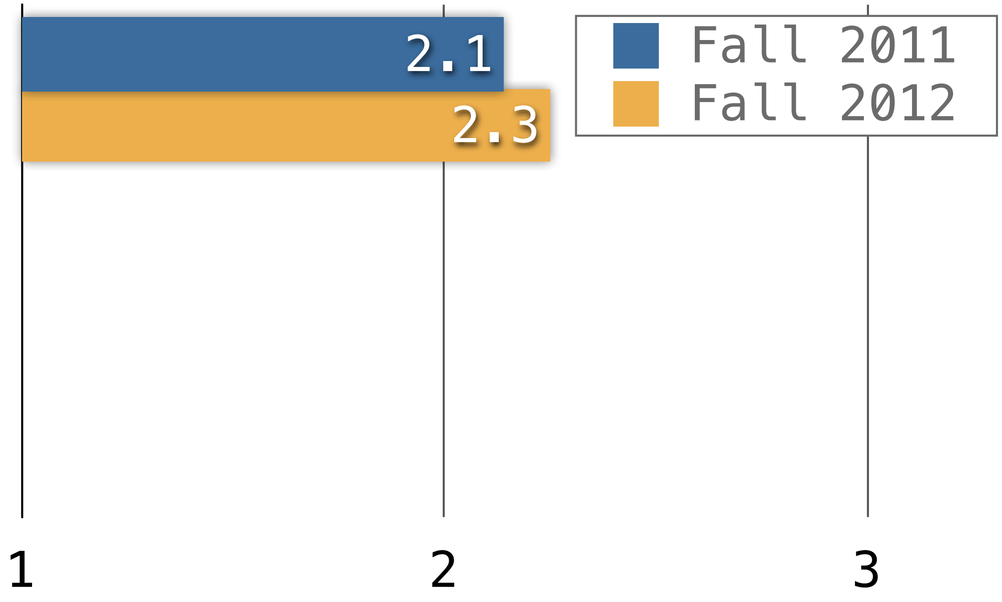
Do names convey the meaning & purpose of their values?



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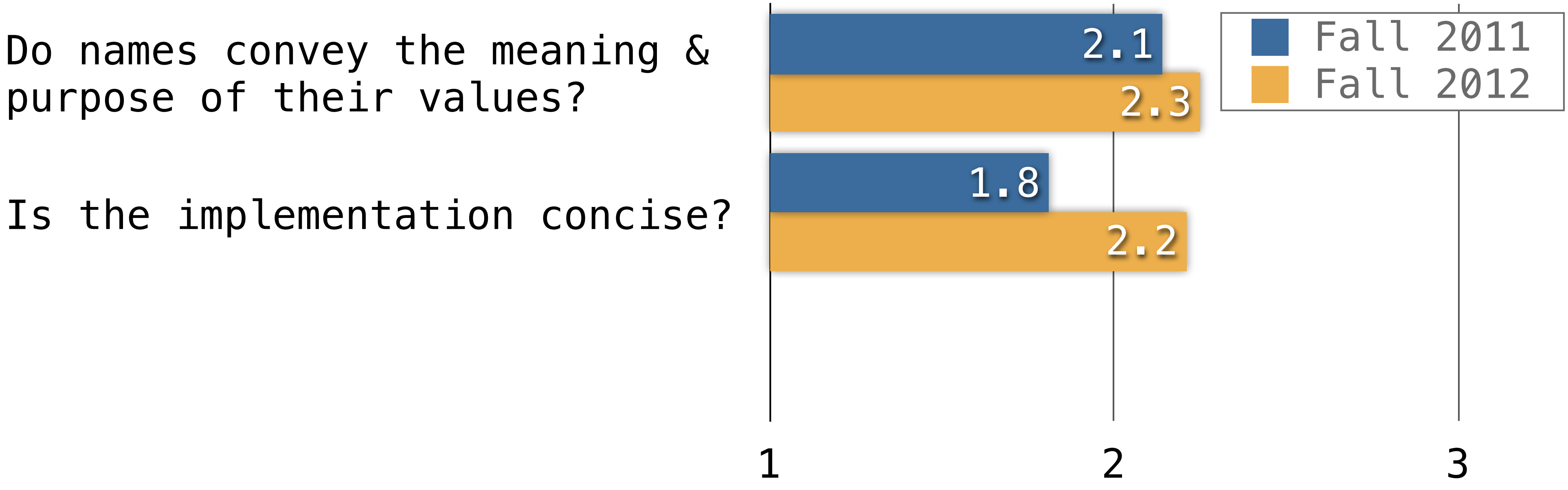

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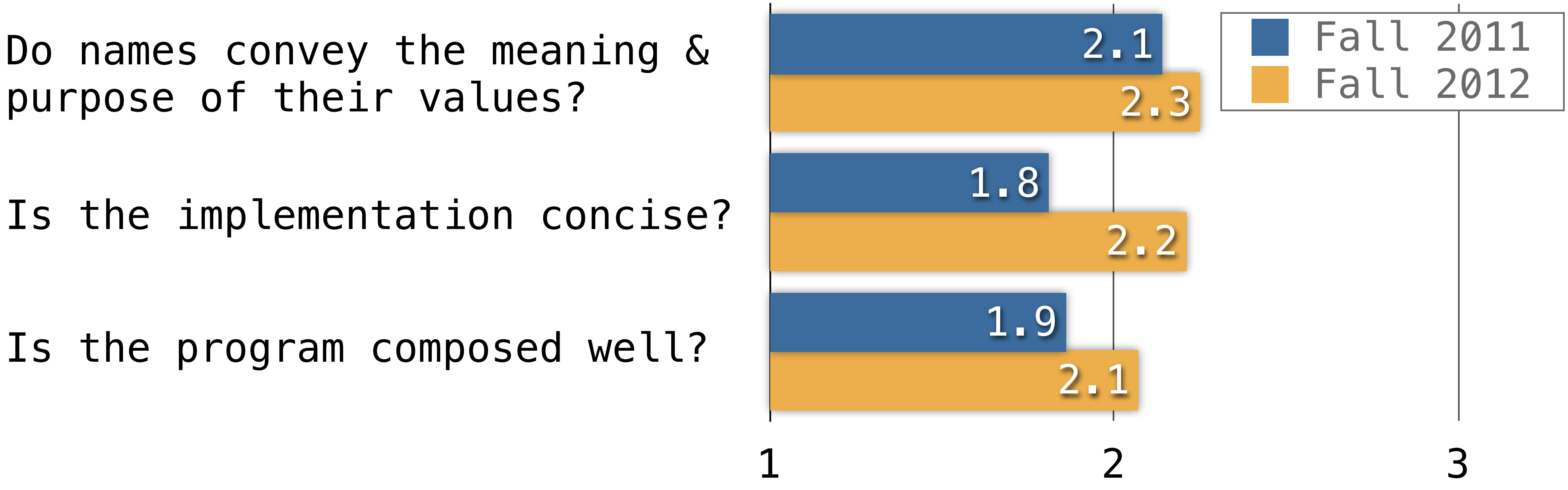

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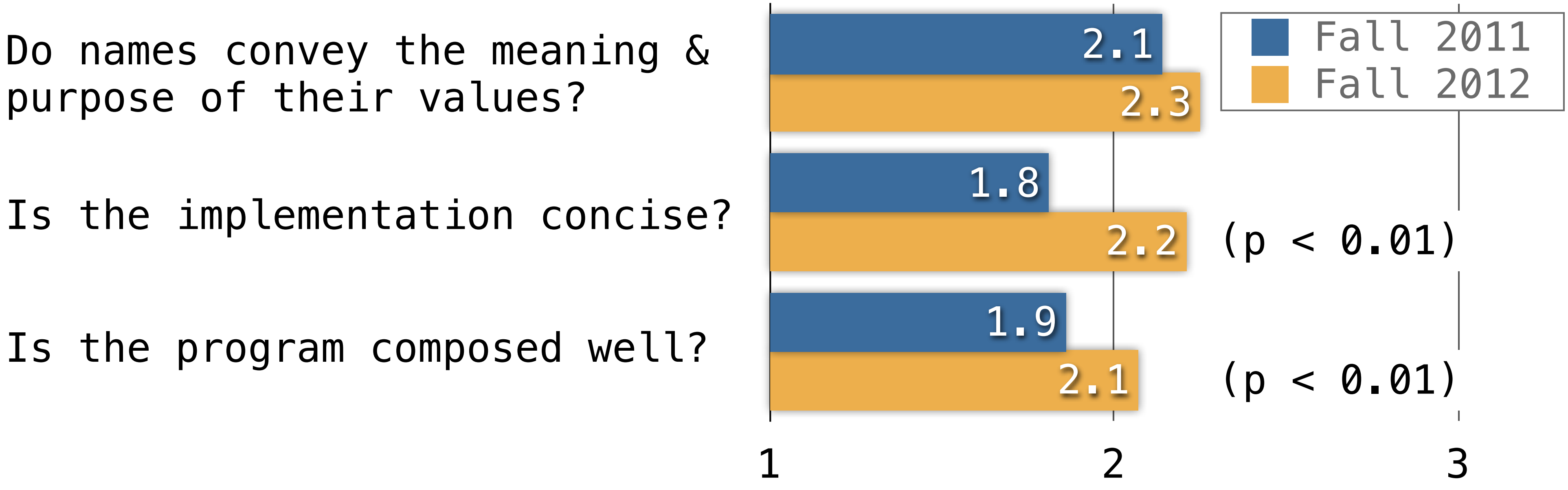

Another Shameless Advertisement

Composing Programs: An Interactive Textbook

ComposingPrograms.com hosts a free online introduction to programming and computer science.

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Demo: http://composingprograms.com/pages/16-higher-order-functions.html#functions-as-arguments

Demo: http://composingprograms.com/pages/23-sequences.html#recursive-lists

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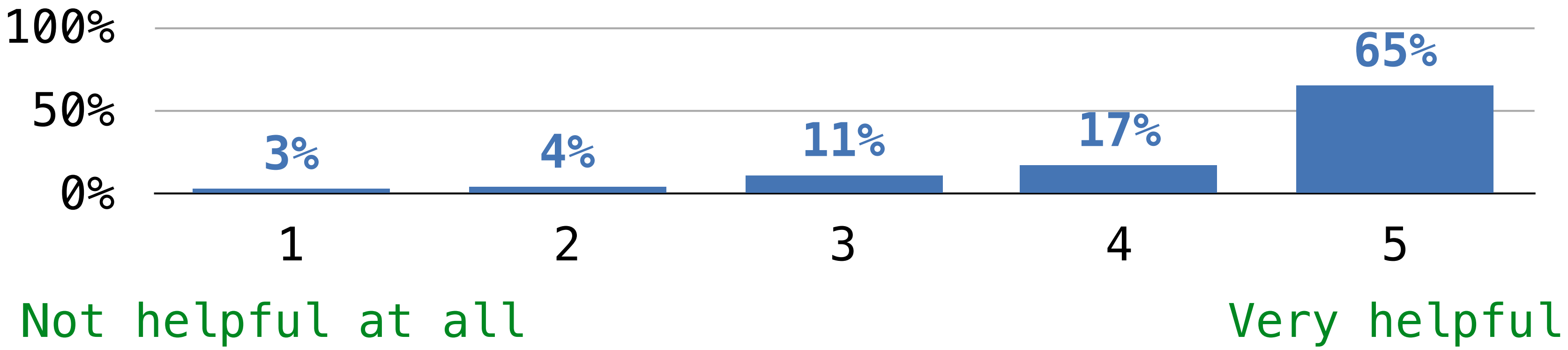
How helpful did you find the online tool for drawing environment diagrams in understanding course material?



Demo: http://composingprograms.com/pages/16-higher-order-functions.html#functions-as-arguments

Demo: http://composingprograms.com/pages/23-sequences.html#recursive-lists

Thanks!

Source Code: github.com/moowiz/ucb-codereview

Description: composingprograms.com/codereview.html

Interested in the Composing Programs textbook?
Please fill out the survey on composingprograms.com!

Extra

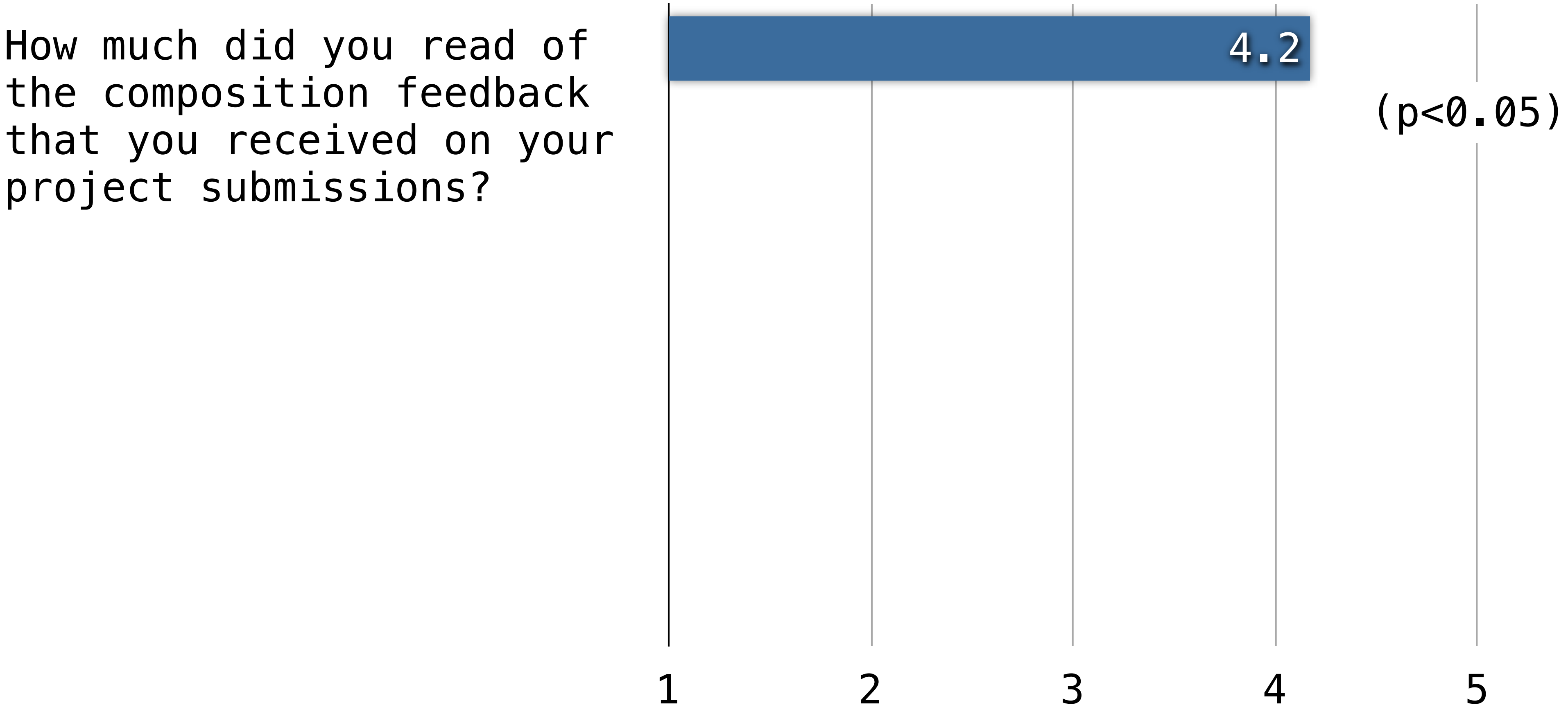
End-of-Semester Survey Results

Fall 2012 Average Responses (Scale from 1 to 5)

($p<0.05$)

End-of-Semester Survey Results

Fall 2012 Average Responses (Scale from 1 to 5)

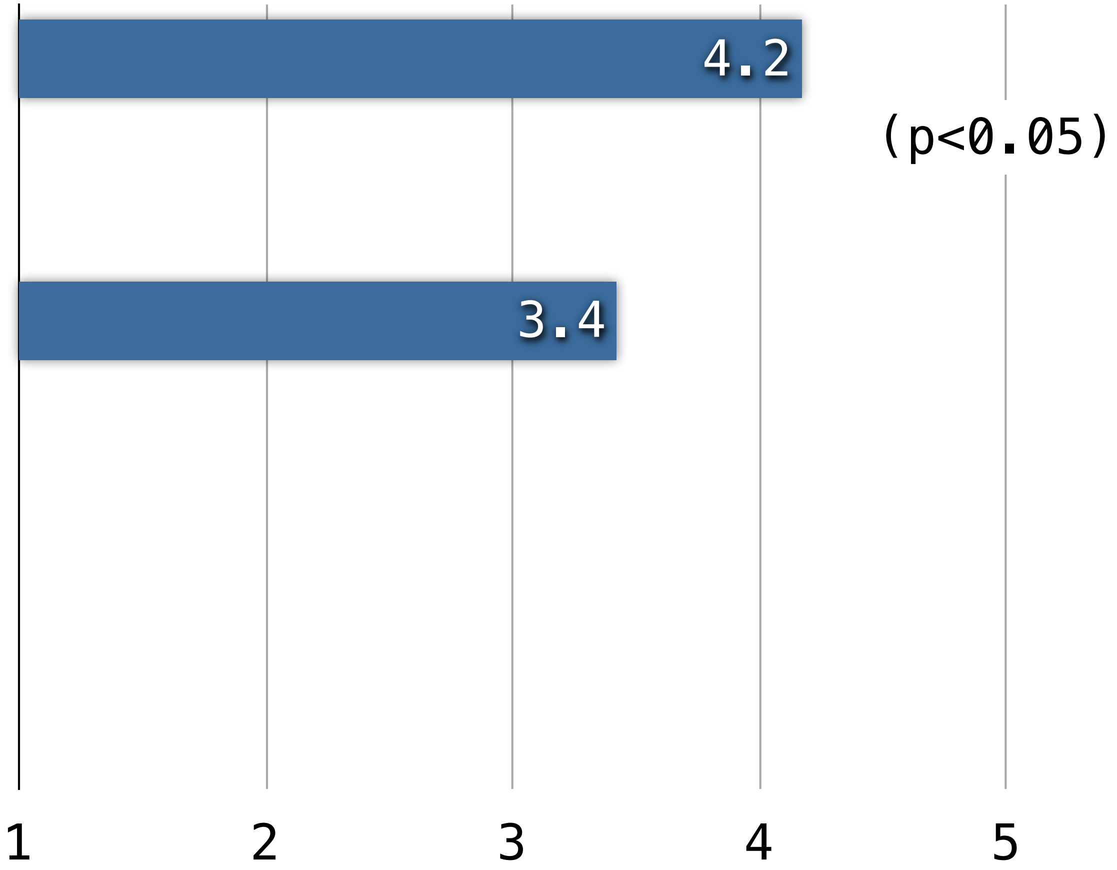


End-of-Semester Survey Results

Fall 2012 Average Responses (Scale from 1 to 5)

How much did you read of the composition feedback that you received on your project submissions?

How helpful was the composition feedback you received?



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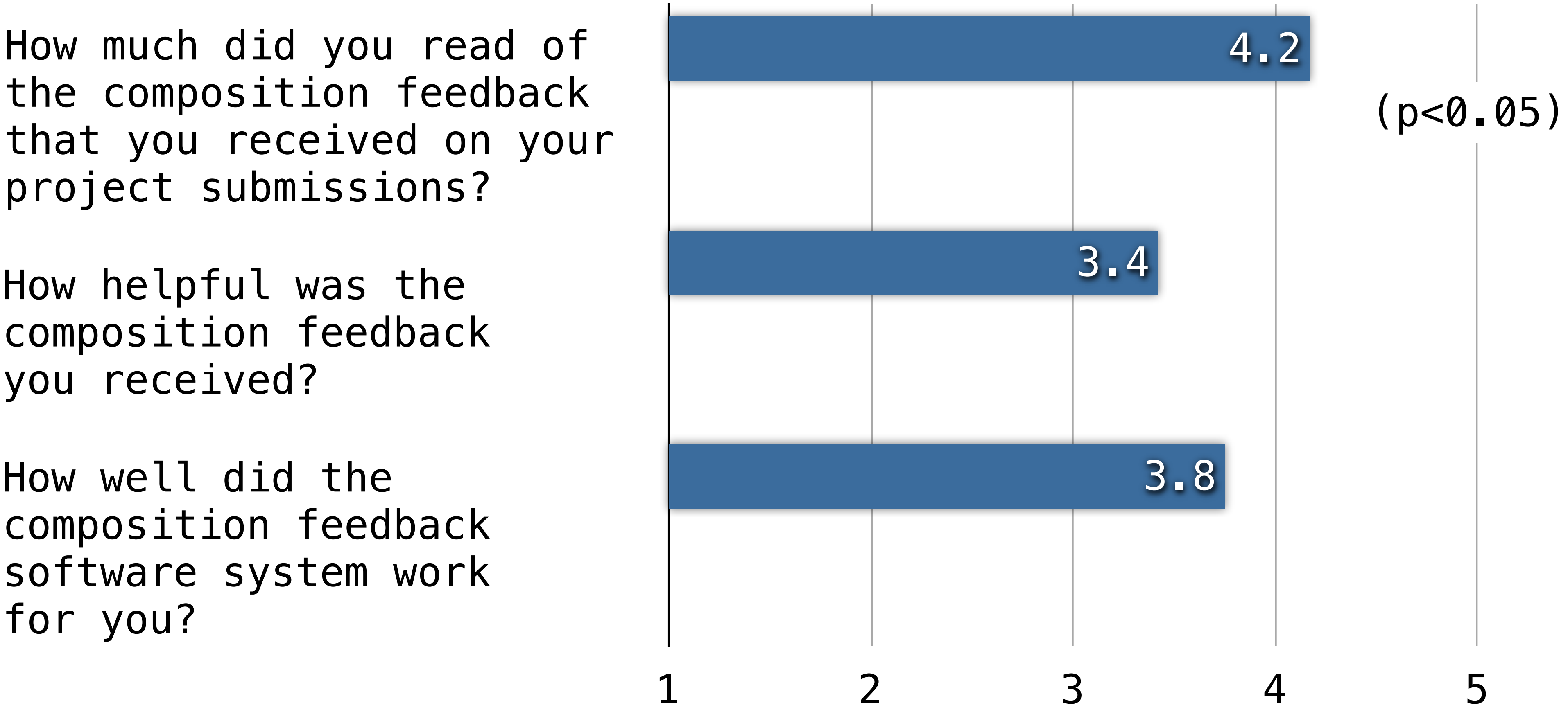

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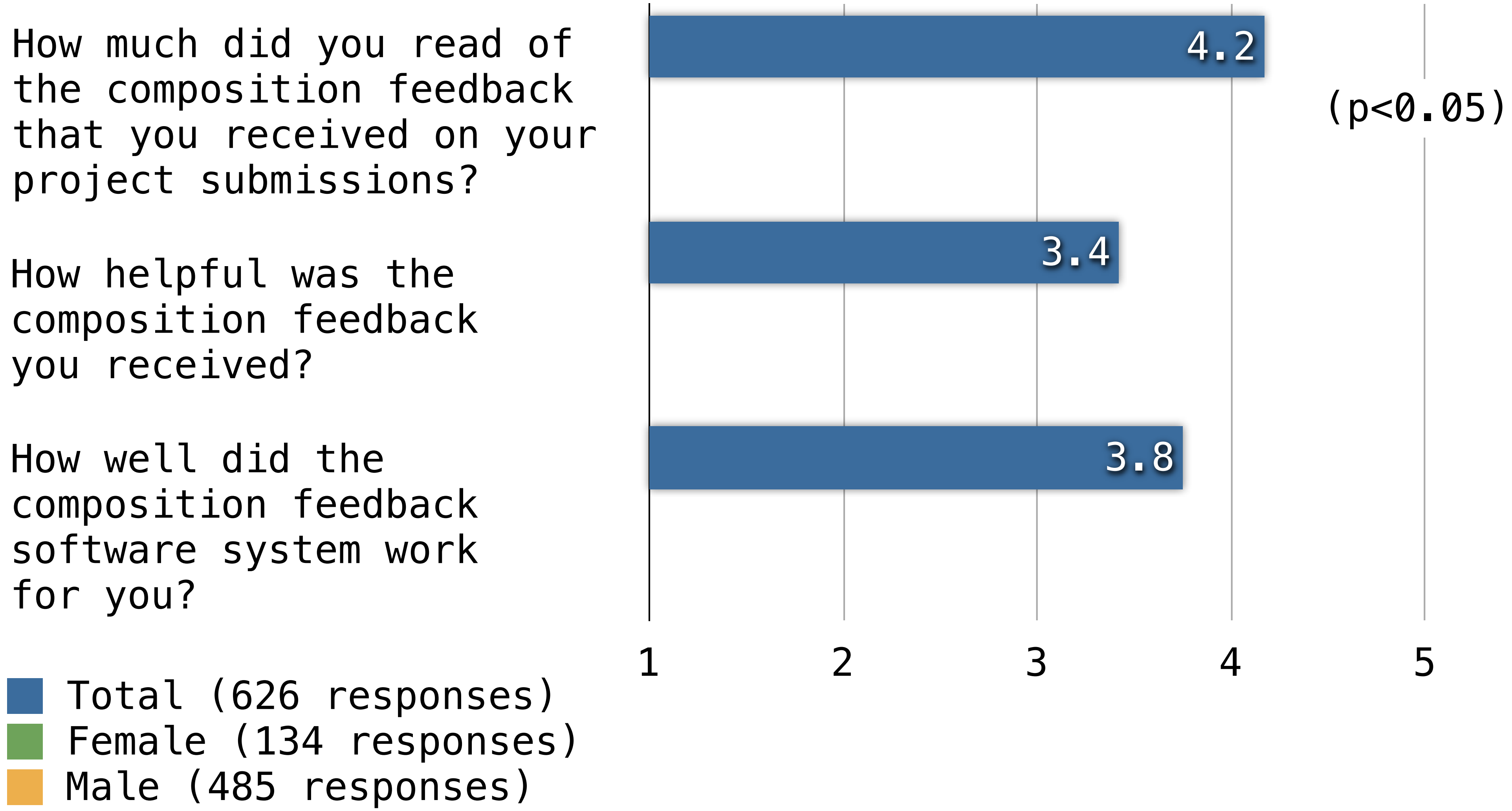

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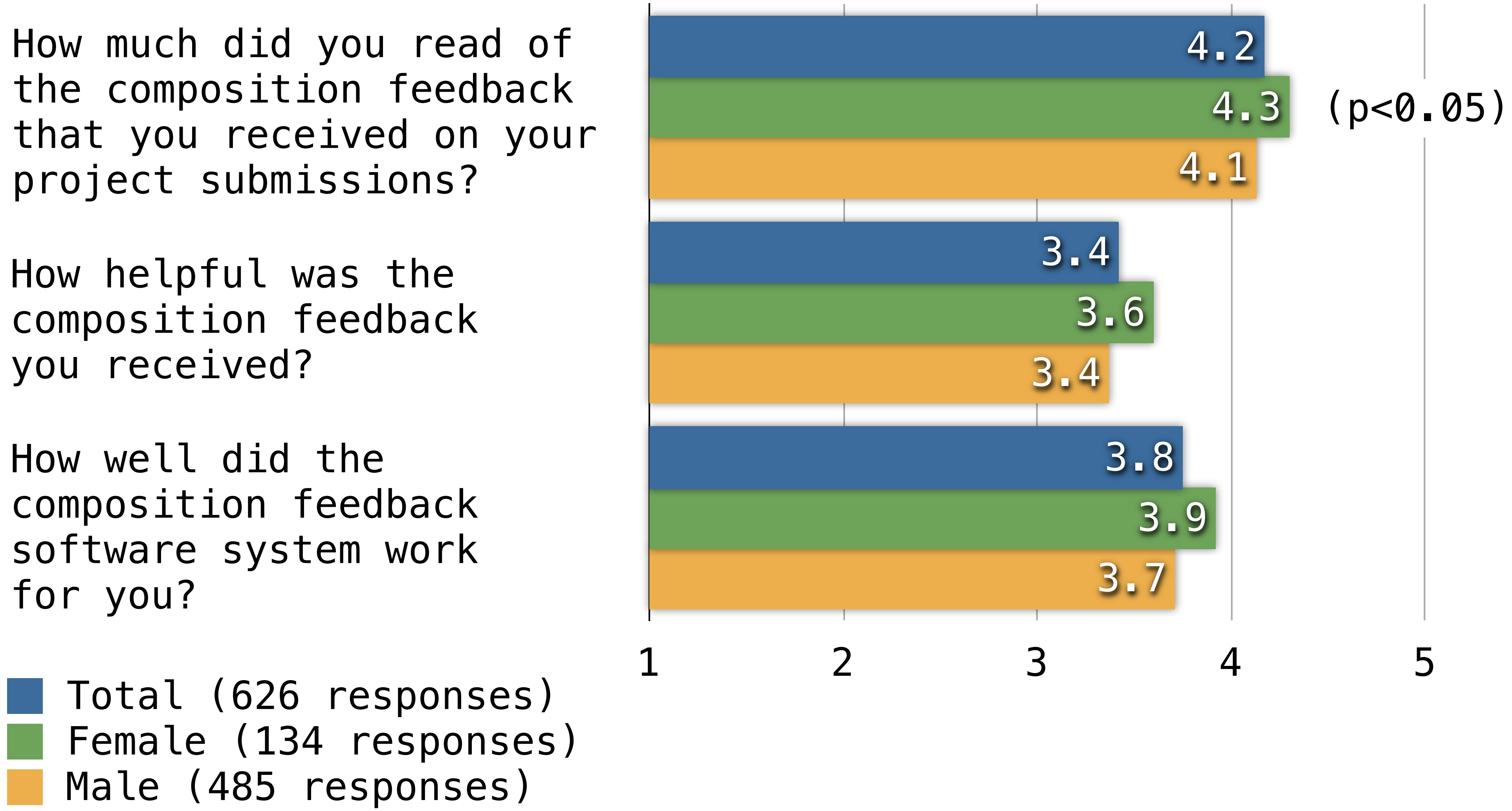
How much did you read of the composition feedback that you received on your project submissions?
(p<0.05)
How helpful was the composition feedback you received?
How well did the composition feedback software system work for you?
🟦 Total (626 responses)
🟩 Female (134 responses)
🟧 Male (485 responses)