Crowdsourced Code Review in Programming Classes

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Problem: Feedback about Coding Style

- MIT 6.005 Software Construction
  - foundation-level programming course (replaced 6.001/6.170)
  - 400 students per year, mostly sophomores
- Students write lots of code
  - roughly 10kloc in problem sets and projects
- Automatic grading is necessary but not sufficient

```
// compute n!  requires n >= 0
int factorial(int n) {
    if (n == 0) return 1;
    else return n * factorial(n-1);
}
```

correct and understandable

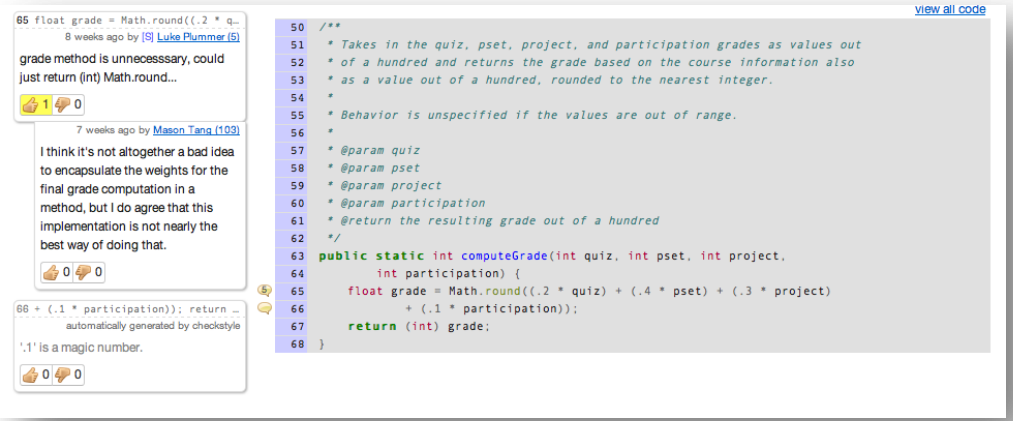
```
int factorial(int n) {
    int i, result=1;
    if (n == 0) result = 1;
    else {
        for (i = 1; i < n; ++i) result *= i;
        result = result*n;
        return result;
    }
    return 1;
}
```

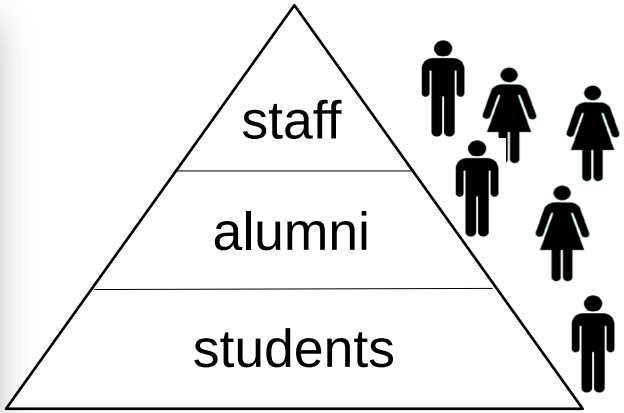
correct but confusing

  - we need human readers, and we want line-by-line feedback

Approach: Crowd-Driven Code Review

- Chop up student programs into **chunks**
- Review the chunks by a **mixed crowd**: students, staff, alums





- Anticipated benefits
  - faster, cheaper, more diverse comments
  - give practice with code reviewing (a widespread industry practice)
  - expose to good and bad solutions
  - reduce workload on teaching staff
  - incorporate alumni back into the course
- Not using for grading... yet

Outline

- ✓ Introduction
- System
  - Caesar code-reviewing system
- Process
  - How we use Caesar in a programming class
- Experience
  - Some results from initial deployment last fall & spring
- Looking ahead
  - Issues to address
  - Opportunities for on-campus and online

Caesar: Divide & Conquer

```java
public class RulesOf6005 {


 /**
  * Tests if the string is one of the items in the Course Elements section.
  *
  * @param name - the element to be tested
  * @return true if <name> appears in bold in Course Elements section. Ignores case (capitalization).
  * Example: "Lectures" and "lectures" will both return true.
  */
 public static boolean hasFeature(String name){
        // TODO: Fill in this method, then remove the RuntimeException
        String[] elements = { "lectures", "recitations", "laptops required", "text", "problem sets", "
        String test = name.toLowerCase();
        for (int ii = 0; ii < 9; ii++) {
                if (elements[ii].equals(test)) {
                        return true;
                }
        }
        return false;
 }


 /**
  * Takes in the quiz, pset, project, and participation grades as values out of a
  * hundred and returns the grade based on the course information also as a value out
  * of a hundred, rounded to the nearest integer.
  *
  * Behavior is unspecified if the values are out of range.
  *
  * @param quiz
  * @param pset
  * @param project
  * @param participation
  * @return the resulting grade out of a hundred
  */
 public static int computeGrade(int quiz, int pset, int project, int participation){
        return (int)Math.round((quiz*.2) + (pset*.4) + (project*.3) + (participation*.1));
 }


 /**
  * Based on the slack day policy, returns a date of when the assignment would be due, making sure not
  * exceed the budget. In the case of the request being more than what's allowed, the latest possible
  * due date is returned.
  *
  * Hint: Take a look at http://download.oracle.com/javase/6/docs/api/java/util/GregorianCalendar.html
  *
  * Behavior is unspecified if request is negative or duedate is null.
```

programs chopped into **chunks**

each chunk assigned to multiple reviewers

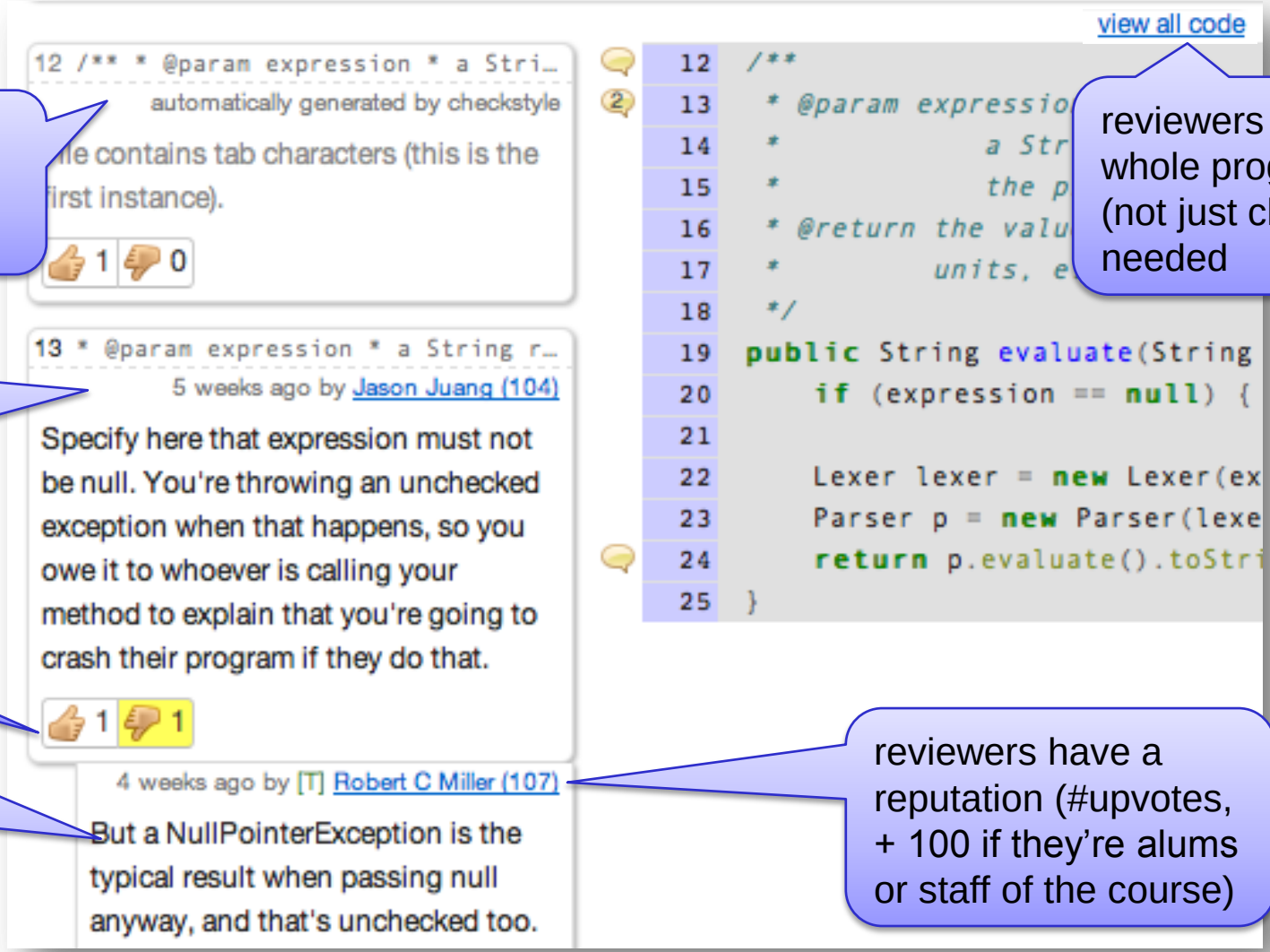
code to review

PrimeFactorsServer	5 1
PrimeFactorsServer	5 1
EchoClient	1 1
EchoClient	5 1
EchoClient	3 1
EchoServer	3 1
PrimeFactorsClient	6 1
PrimeFactorsServer	6 1
EchoClient	2 1
EchoClient	2 1

code recently reviewed

RulesOf6005.extendDeadline(..)	18 2
RulesOf6005.extendDeadline(..)	4 3
RulesOf6005.computeGrade(..)	9 3
RulesOf6005.extendDeadline(..)	6 2
RulesOf6005.computeGrade(..)	6 3
RulesOf6005.hasFeature(..)	3 2
RulesOf6005.hasFeature(..)	6 2
RulesOf6005.hasFeature(..)	4 2
RulesOf6005.hasFeature(..)	5 2
RulesOf6005.hasFeature(..)	4 2

Social Reviewing



automatic style checker comments

reviewer comments

upvotes & downvotes

replies & discussion

reviewers can see whole program (not just chunk) if needed

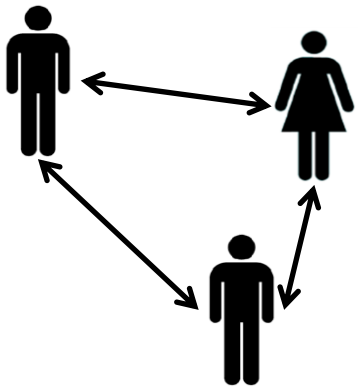
reviewers have a reputation (#upvotes, + 100 if they're alums or staff of the course)

Code Chopping

- Chop each submission into chunks
  - We've tried two sizes: method (~20 loc) and class (~150 loc)
- Sort chunks
  - Prioritize classes marked important by staff
  - Diff against staff-provided code and prioritize chunks with more student-authored lines
  - Deprioritize test code
  - Cluster chunks using MOSS fingerprinting
- Not all chunks get assigned for review
  - Typically 30%
  - So prioritization is important

Task Routing

- Lazy assignment
  - wait until a reviewer logs in before assigning tasks to them, since a given alum/student may or may not show up
- Multiple reviewers per chunk
  - assign 2 students/alums to a chunk to encourage discussion
  - assign 1 staff to the chunk too, for reviewing the reviews
- Fairness to code author
  - balance #reviewed chunks per submission
- Diversity of learning opportunities
  - maximize differences between reviewers on same chunk & same submission
    - role (student, alum, staff)
    - reputation score
    - # times assigned to a chunk together



Privacy vs. Visibility

- Code author is anonymous
- All reviewers are identified & their reviews are browsable

all users

- Mason Tang (masont)
- Robert C Miller (rcm)
- Stephanie Yu (styu)
- Jennifer Li (jennyli)
- Elena Tatarchenko (elena_11)
- Timothy Kaler (tfk)
- Tana Wattanawaroon (tana)
- Warut Suksompong (warutsuk)
- Panupong Pasupat (ppasupat)
- Stephen A Freiberg (saf)
- Aysylu Biktimirova (aysylu)
- Tamara Fleisher (tfleish)
- Usman Masood (usmanm)
- colleen josephson (cjoseph)
- Maksim Kolysh (mkolysh)
- Ivan Borsenco (borsenco)
- Pedram Razavi (Prazavi)

Robert C Miller

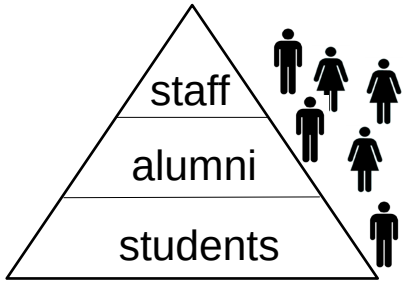
rcm
reputation: 107

ps3

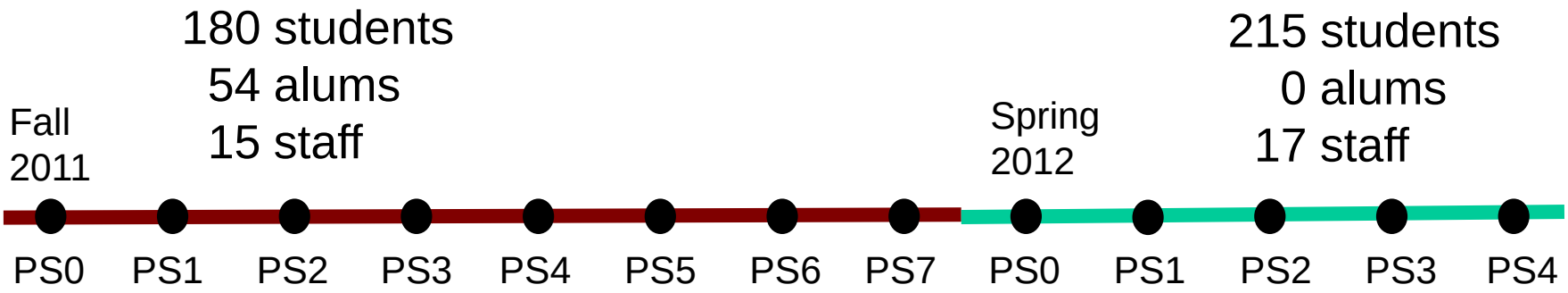
- Also, it might be a good idea to append some sort of general error indicator to the except...
- I would suggest against catching every error of every possible type; instead, focus on cal...
- What if you get a blank string, or a string with improper grammar?
- Looks good. Simple and elegant. Are you throwing only RuntimeExceptions? I'm assuming your...
- Why not just throw the exception? What if there's an error in the lexer?
- Your specs could use a little more detail, but the code looks fine.
- Right. Rep exposure!
- Looking at your implementation of Parser, this would be okay if result were final. However...
- The fact that this can return an error should be in the spec.
- I would argue that this exception should be thrown rather than caught. Otherwise, anyone ...
- but would be better to throw as an exception rather than returning as a string. Likewise ..
- That's fair. Hmm, maybe the course instructors should not put code in Ceasar if the author...

Process

- Assignment due on Thurs
- Students review Fri/Sat
  - 10 chunks; must comment or vote on each
  - assignment is still fresh in their minds, curious about other's solutions
- Staff reviews Sun
  - 30 chunks; mostly voting
- Alums review whenever (Fri-Wed)
  - 3-5 chunks; must comment or vote
- Revise & resubmit assignment by Thurs
  - Main motivation is to fix bugs that lost points in autograding, but must address code review comments as well



Experience



13 problem sets, 2.2k submissions

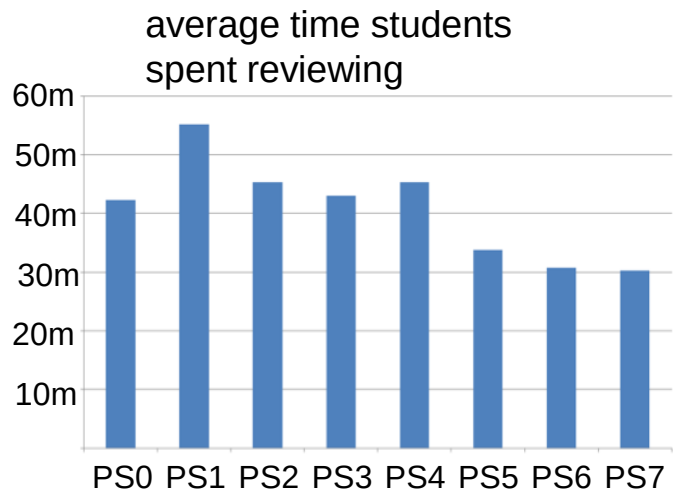
21.5k comments

- 5% alums
- 8% staff
- 87% students

16.2% upvoted

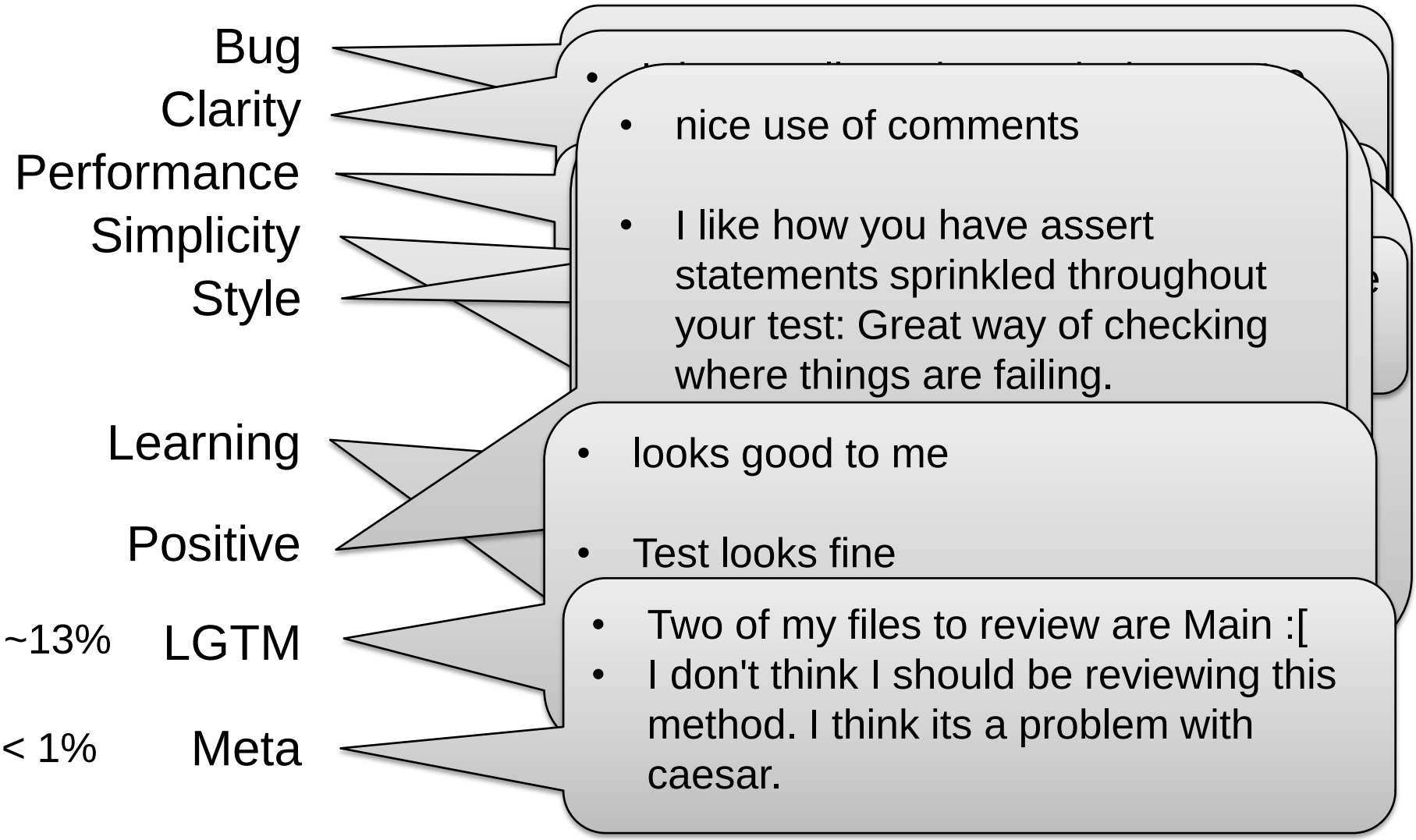
0.7% downvoted

9.6 comments per submission



MIT HUMAN-COMPUTER INTERACTION

Kinds of Comments



Interaction Happened

- 16% of comments were upvoted
- 22% of comments were in conversations (threads with at least 2 human comments)

- Corrections
- Clarifications
- Author responses

- student: Prefer equalsIgnoreCase because it says to ignore capitalization
  - student: The name = name.toUpperCase line seems to take care of capitalization.

- student: Agreed. I think the desired method here is add, not roll

- student: what does this method do?
  - code author: Essentially assertEquals. As someone else pointed out, this should have been an assert array equals, so that will happen in the future.

Alums Have Different Context

- alum: avoid abbreviating variable names... 'hi' would be especially confusing to someone who isn't familiar with english
- student: Idk about this one though. I've seen lo and hi at various places. I'd say this is fine. Though, the integer N should be lower case, just to conform with the java naming convention.
- alum: **When you're in industry and working on code with people who aren't necessarily familiar with English**... it's a problem to use phonetic abbreviations. There is really no good reason to abbreviate variable names especially since IDEs autocomplete.
- student: For that, yes, I agree. Sadly, some IDEs don't autocomplete very well. *cough*
- code author: These were the variables that were **given to us**

Reviewers Repeat Themselves

- staff: A magic number is a some fixed constant (numbers, Strings, etc.) used in a place where variables would likely add to code clarity or understanding...
- staff: Magic numbers are simply primitives that are used without having a descriptive variable name...
- alum: Returning null is usually dangerous, especially if your Javadoc doesn't mention that it might return null in some cases...
- alum: Don't return null in exception cases, especially if your Javadoc's @return line doesn't mention the possibility of returning null (even though it's mentioned earlier)....
- student: Should include more in rep invariant. ie a digit is allowed only once per row, column, and box
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Some Code Authors Are Self-Conscious

```
91    * You have been warned! DO NOT VIEW THIS FUNCTION
92    */
93   public Lexer.Token recurse(List<Lexer.Token> tokens) {
94
95  //          ///   ///   /////////   ///////    /////////        ////////    /////////
96  //          ///   ///   ///         ///   ///   ///              ///   ///   ///
97  //          /////////   /////////   ///////    /////////        ////////    /////////
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127 // image taken from: http://www.chris.com/ascii/index.php?art=creatures%2Fdragons
```

Survey Responses

- Learning
  - I thought it was helpful. There are **more things I'll be looking for when I code because I saw them in other people's code and people commented** about it.
  - I like how reviewing the code after we've submitted it **allows us to retain the information** and concepts for a longer time.
- Self-doubt
  - I **think I have more to learn than to offer**, at this point though.
  - I was glad that the **code I was assigned were on the parts that I had understood** in my submission, so I could give better feedback.

Survey Responses

- Skepticism
  - Meh. I **don't think this will have a major impact** on students' coding.
  - No; **I'm fixing code instead of learning**.
- Keen to give and get more
  - Is it **alright to review more** than what is assigned on Caesar? I really like reading and reviewing other people's code, but don't know if over-reviewing would be frowned on.
  - I'm **thrilled** to get 51 human comments, but they are **ALL**, somehow, **on tests**.
- Scary
  - Very good UI. I enjoy commenting on code. I feel like the **Simon Cowell of code review**.

Related Work

- ColorMyGraph [Blank, Sutner, von Ahn]
  - crowd grading of proofs
- Github
  - social commenting on code commits
- Code Review StackExchange
  - threaded Q&A about short code chunks

Looking Ahead

- System changes
  - Capturing common advice in a wiki
  - Increasing reviewer leverage: searching for similar code
  - Promoting good comments for all users to read
  - Alumni engagement: recruiting, social networking, reputation management
- Other possibilities
  - Combining automatic grading (e.g. online tutors) with crowd-driven human feedback
- System is open source
  - http://github.com/uid/caesar-web