Code Defenders

Crowdsourcing Effective Tests and Subtle Mutants with a Mutation Testing Game

José Miguel Rojas, Thomas White, Benjamin Clegg, Gordon Fraser

On Fault-revealing Tests

by Brian Hillegas (Flickr)

Manual Testing

Writing good tests is difficult and time-consuming.

EVOSUITE

Randoop

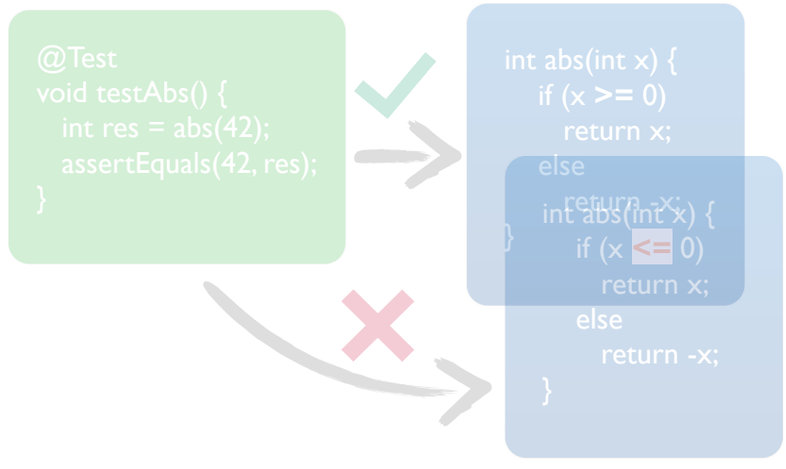
Automatic unit test generation

AgitarOne

Putting Java to the Test

Test Generation

High coverage, but weak assertions.



Mutation Testing

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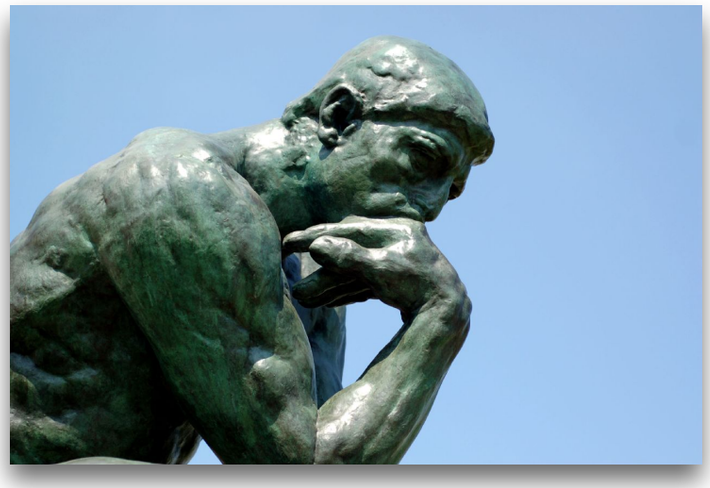

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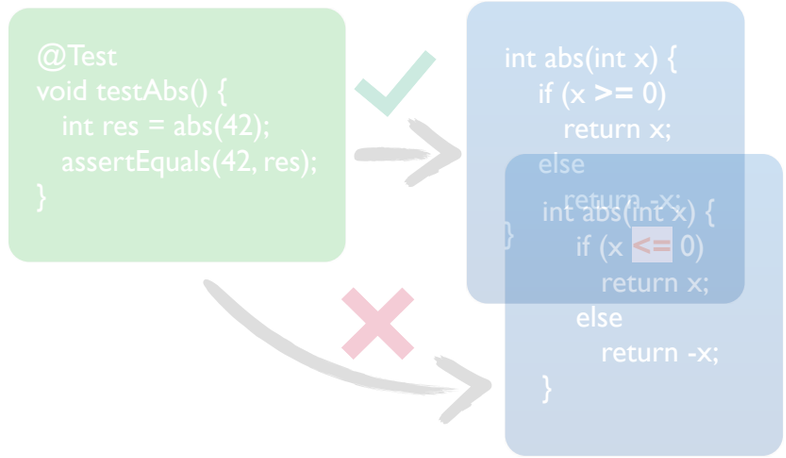

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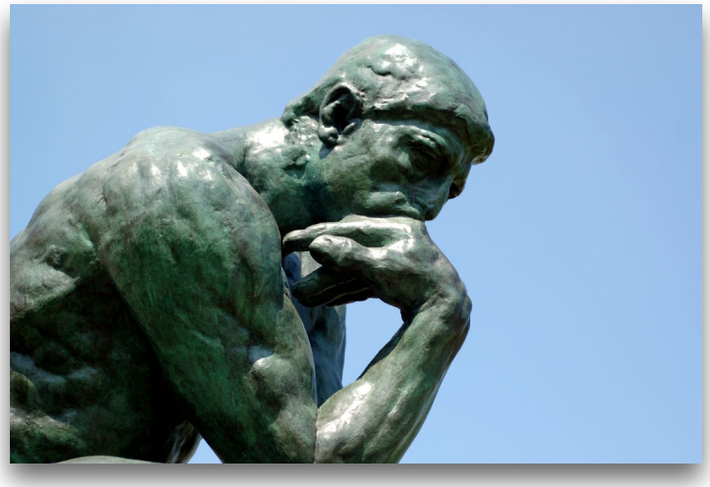

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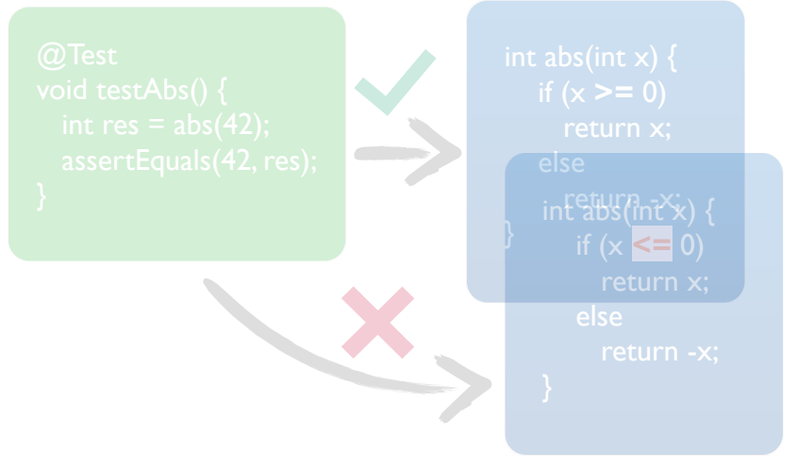

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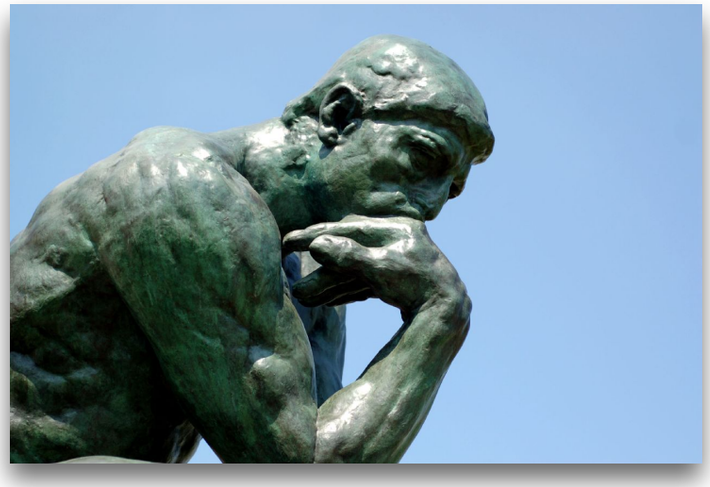

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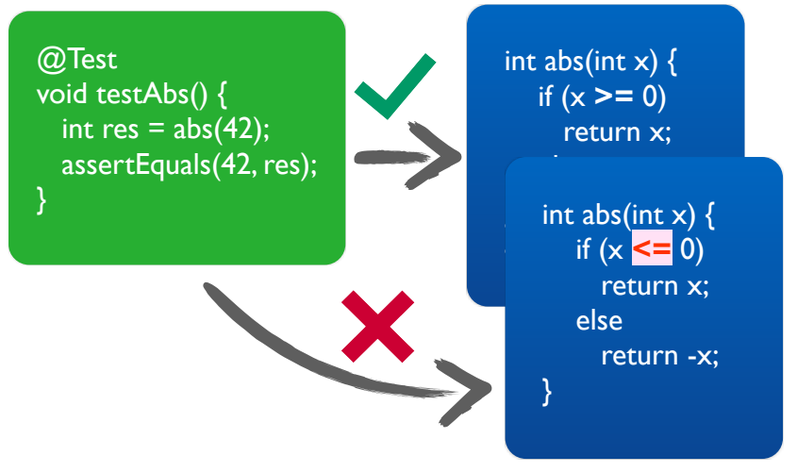

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Software Testing Gamification

Supporting software testing education

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Crowdsourcing tests and mutants

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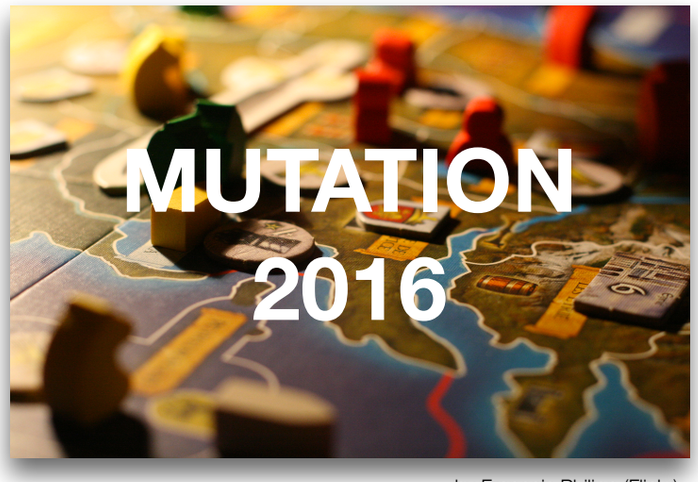

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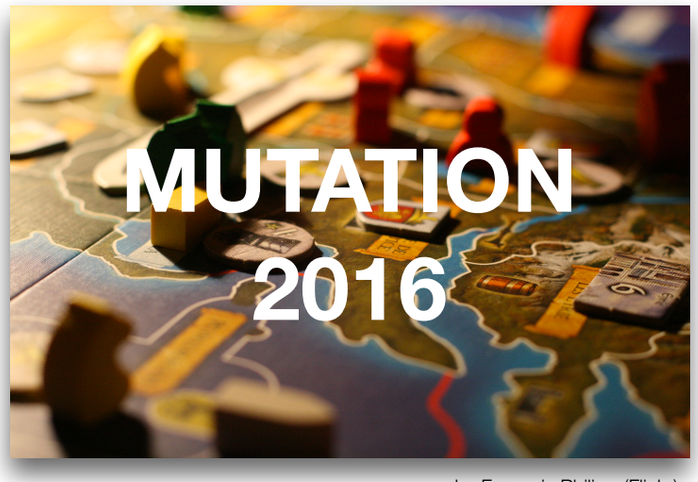

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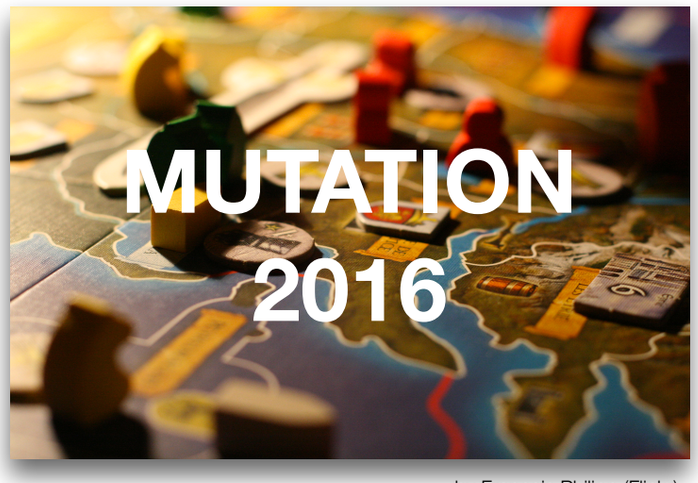

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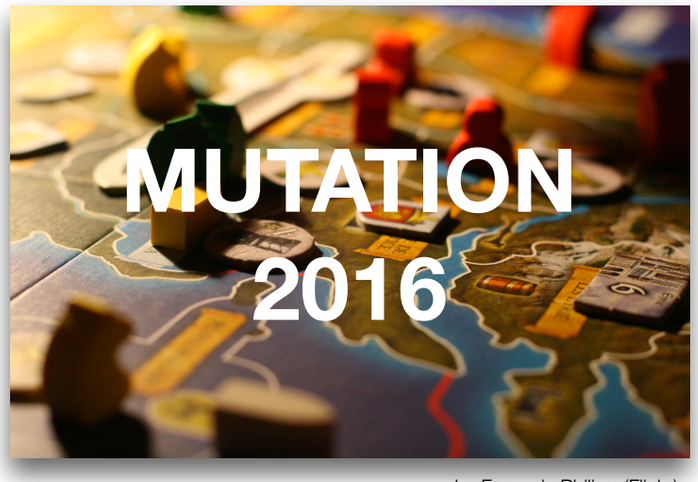

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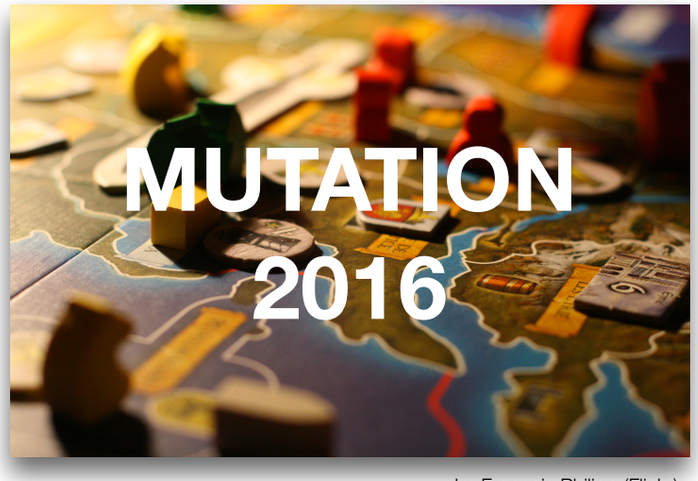

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Crowdsourcing tests and mutants

Code Defenders

Class Under Test

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public class Arithmetics {
   public int abs(int x) {
     if (x >= 0)
         return x;
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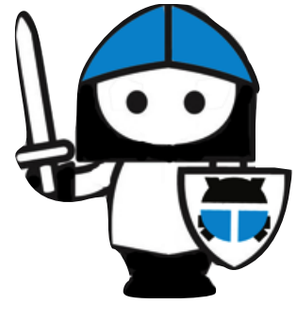

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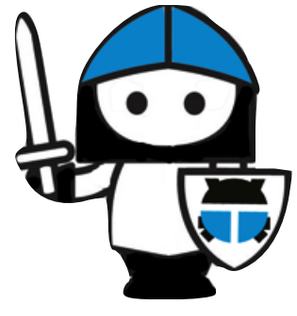

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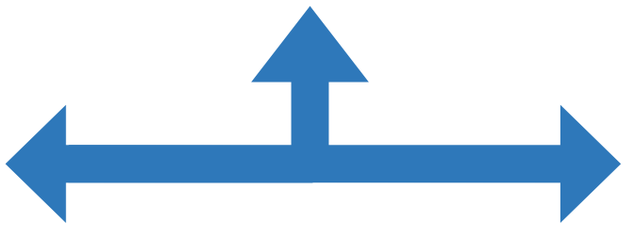

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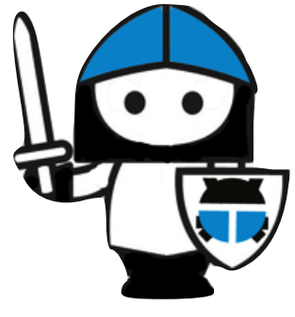

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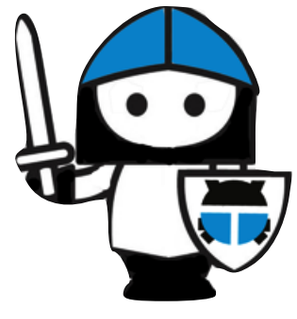
Equivalent Mutant Duels



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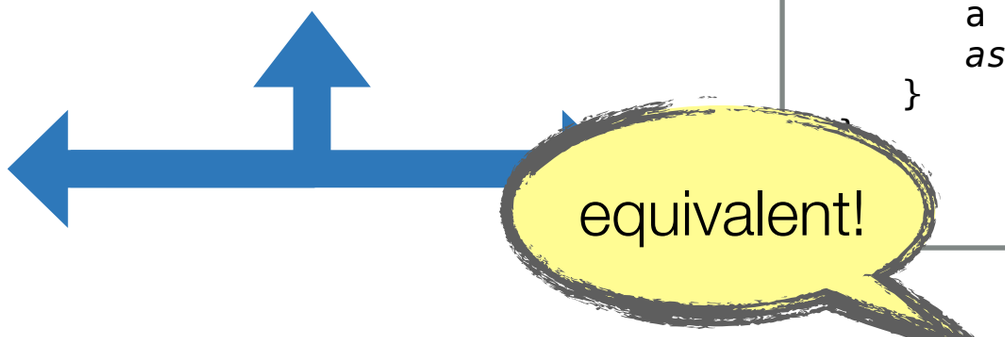

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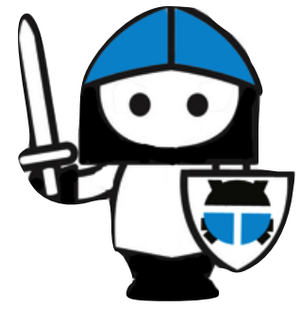

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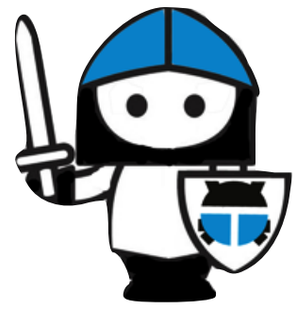

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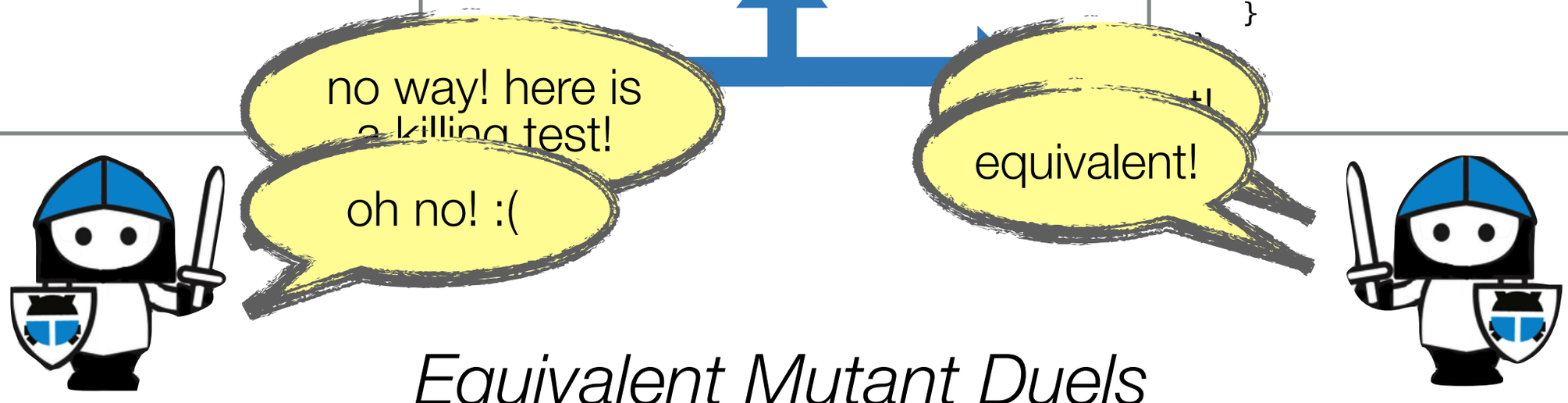

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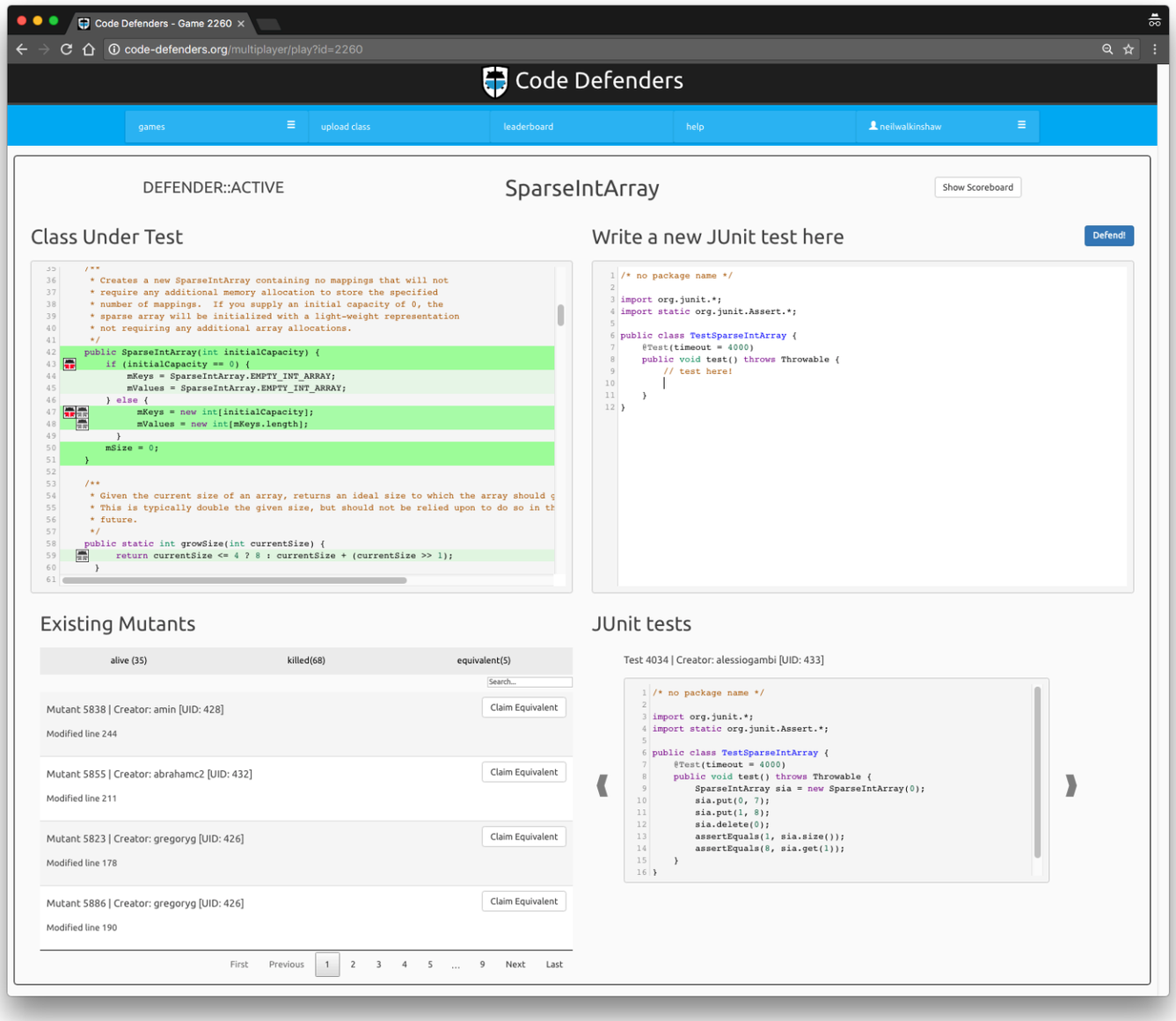

Single-player

vs.

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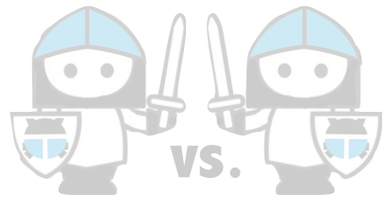
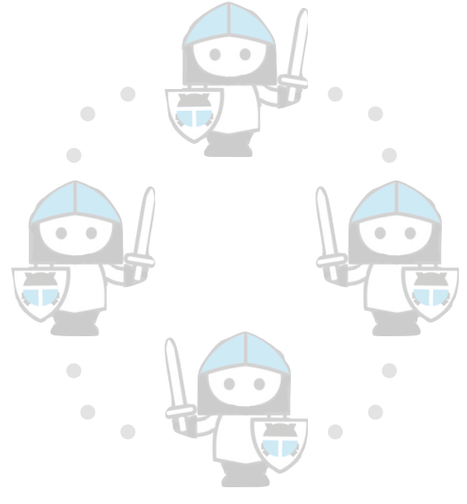


Two-player



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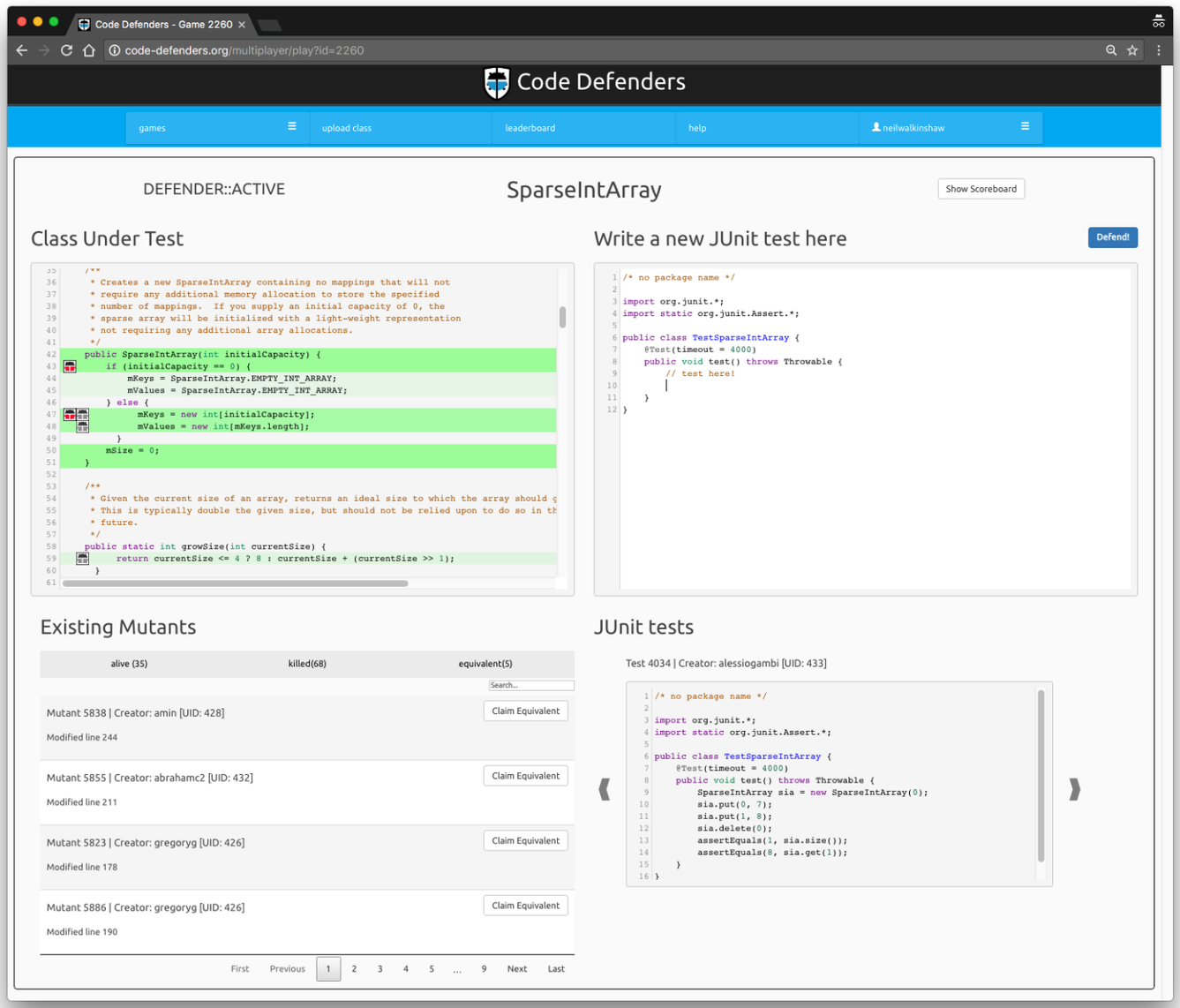

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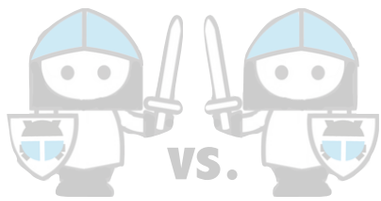

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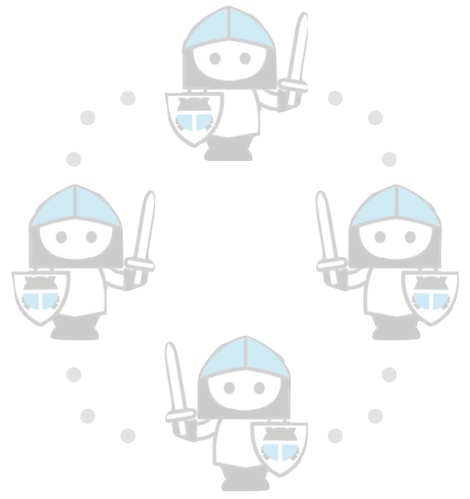

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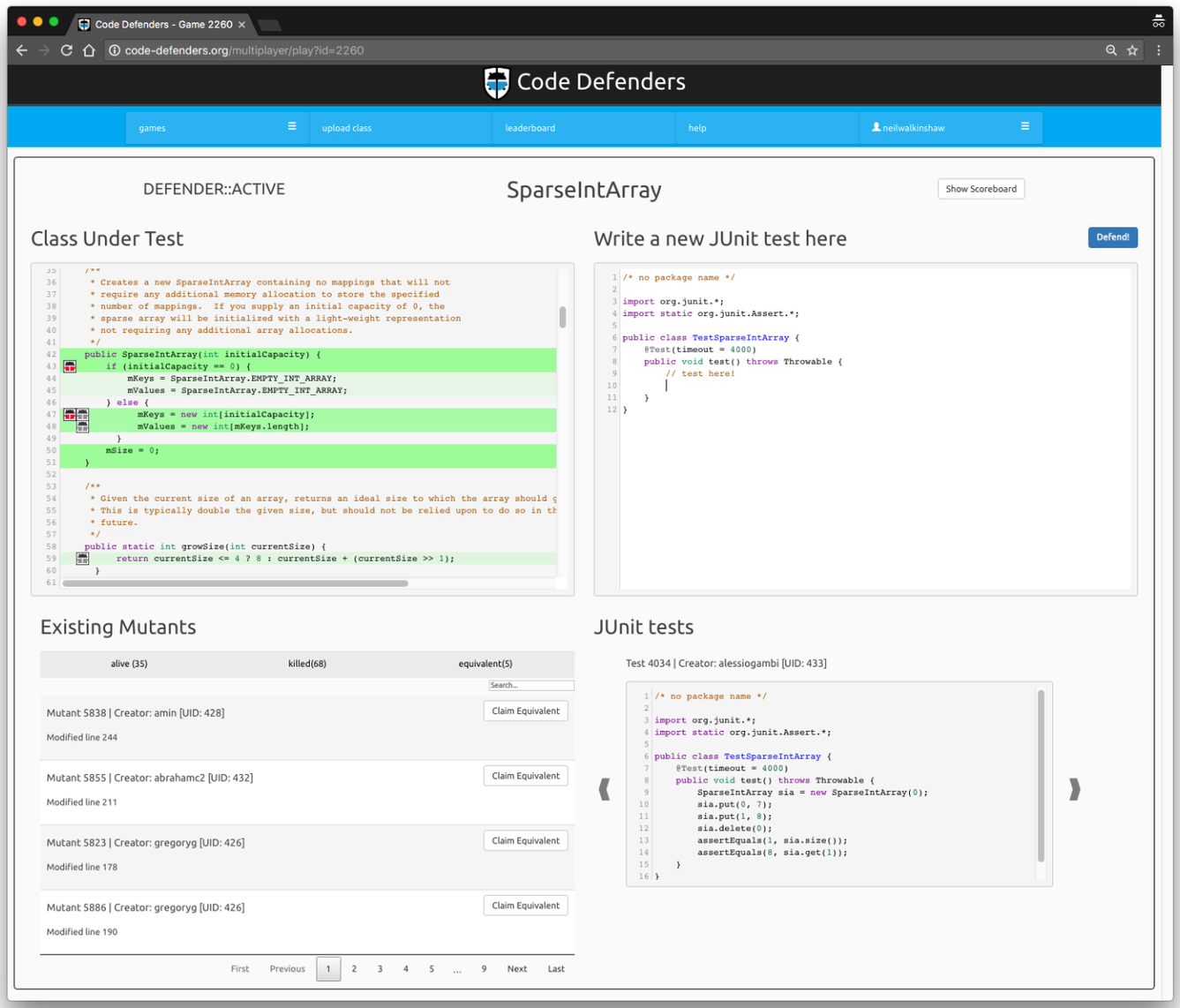

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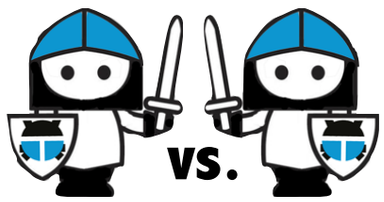

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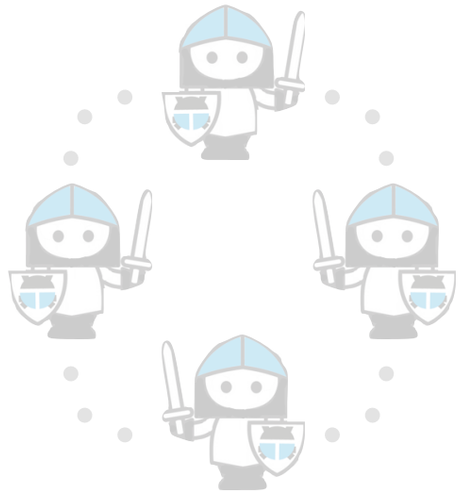

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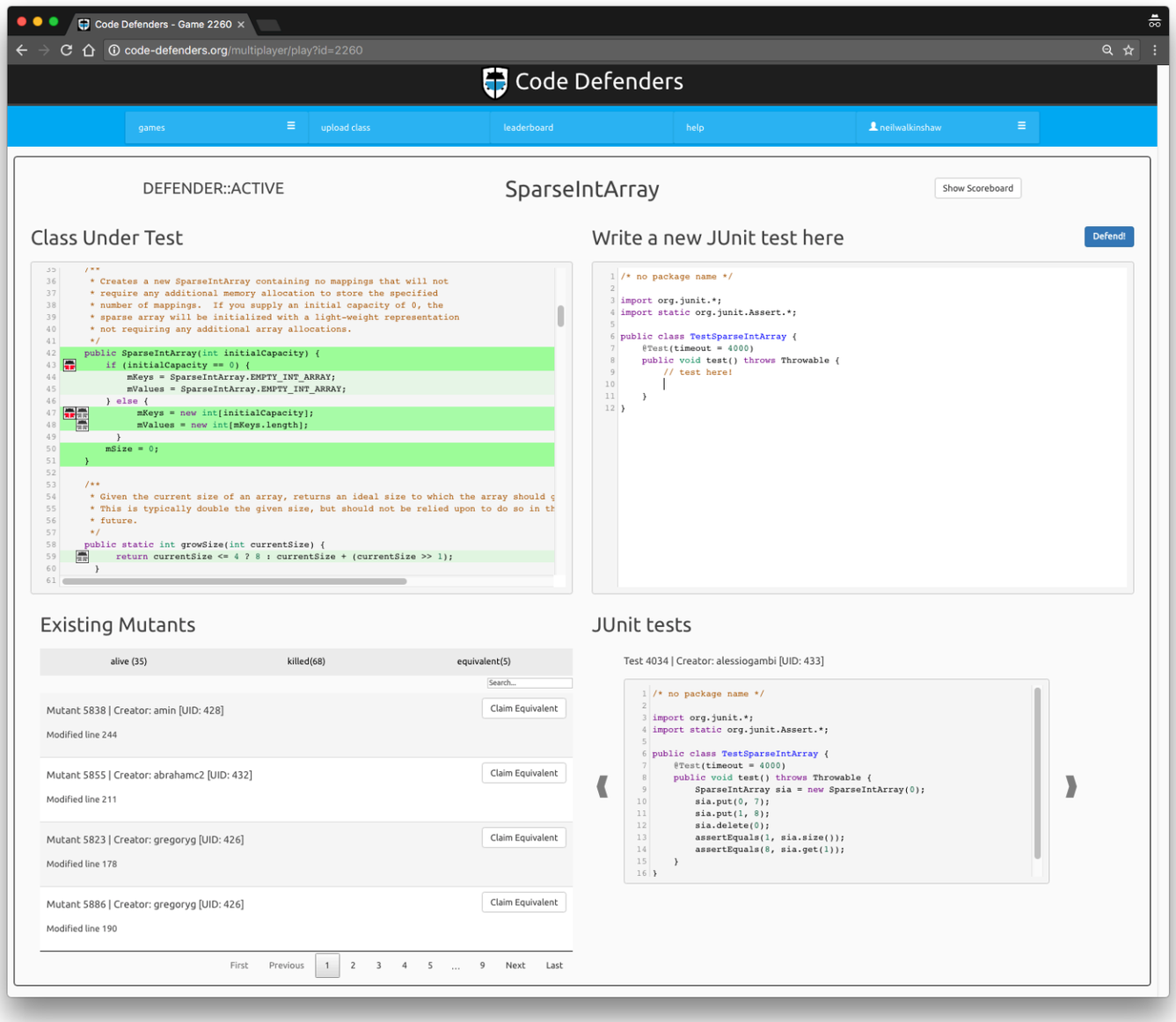

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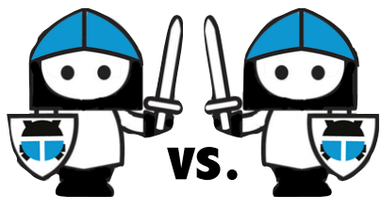

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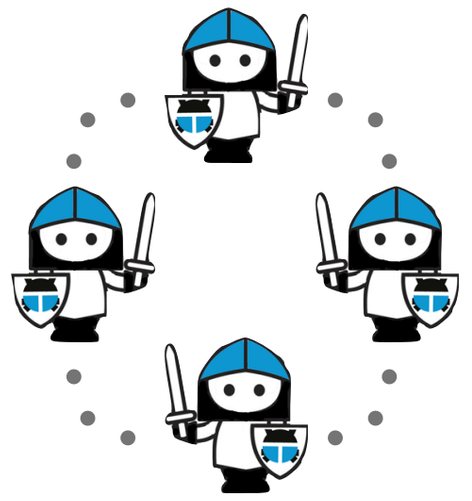


Multi-player

Code Defenders

DEFENDER::ACTIVE

SparseIntArray

Class Under Test

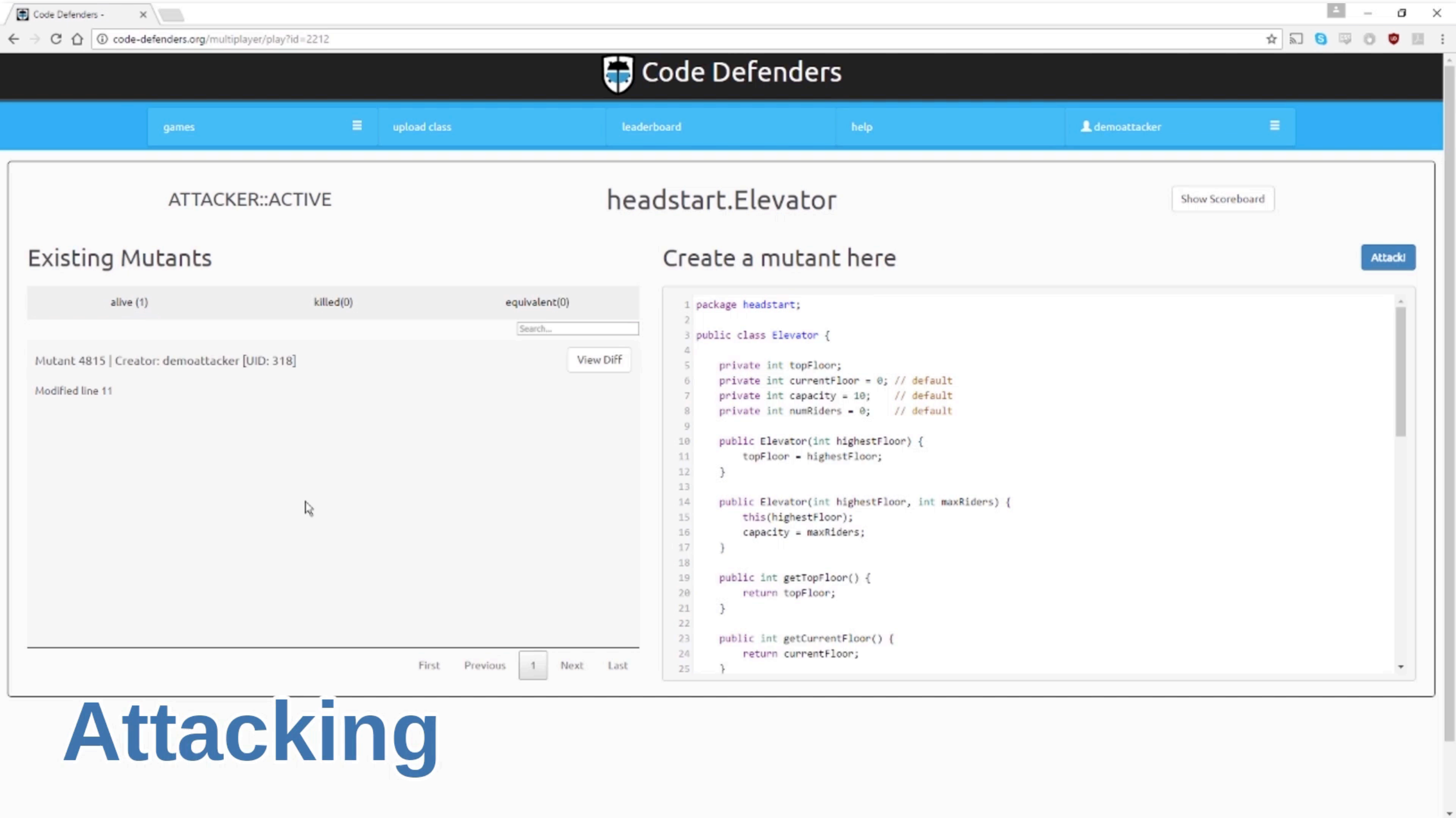
```
35      /**
36       * Creates a new SparseIntArray containing no mappings that will not
37       * require any additional memory allocation to store the specified
38       * number of mappings.  If you supply an initial capacity of 0, the
39       * sparse array will be initialized with a light-weight representation
40       * not requiring any additional array allocations.
41       */
42      public SparseIntArray(int initialCapacity) {
43          if (initialCapacity == 0) {
44              mKeys = SparseIntArray.EMPTY_INT_ARRAY;
45              mValues = SparseIntArray.EMPTY_INT_ARRAY;
46          } else {
47              mKeys = new int[initialCapacity];
48              mValues = new int[mKeys.length];
49          }
50          mSize = 0;
51      }
52
53      /**
54       * Given the current size of an array, returns an ideal size to which the array should g
55       * This is typically double the given size, but should not be relied upon to do so in th
56       * future.
57       */
58      public static int growSize(int currentSize) {
59          return currentSize <= 4 ? 8 : currentSize + (currentSize >> 1);
60      }
61
```

Write a new JUnit test here

```
1  /* no package name */
2
3  import org.junit.*;
4  import static org.junit.Assert.*;
5
6  public class TestSparseIntArray {
7      @Test(timeout = 4000)
8      public void test() throws Throwable {
9          // test here!
10
11     }
12 }
```

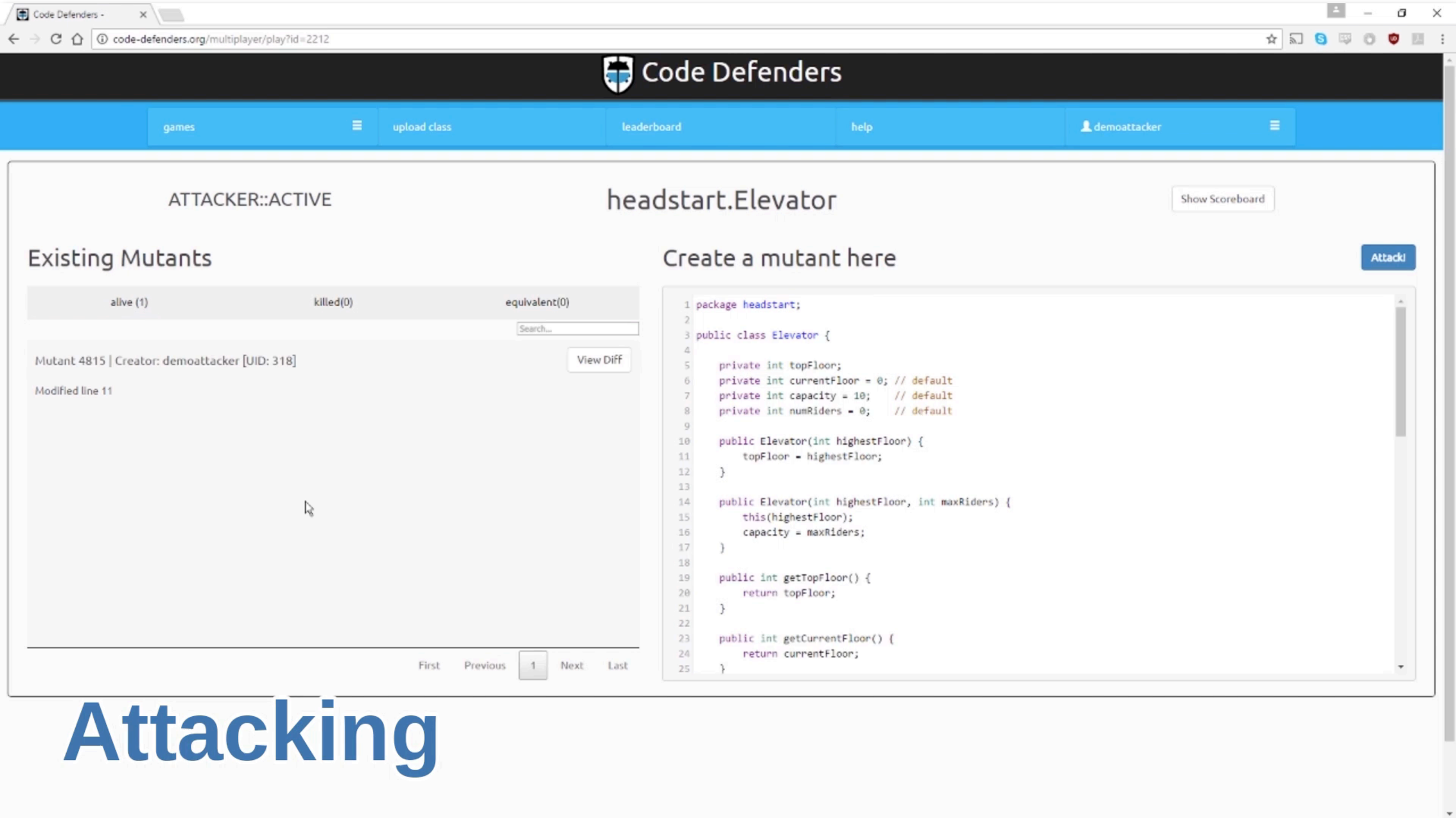
Existing Mutants

JUnit tests



Attacking

ICST'17 Best Tool Demo Award



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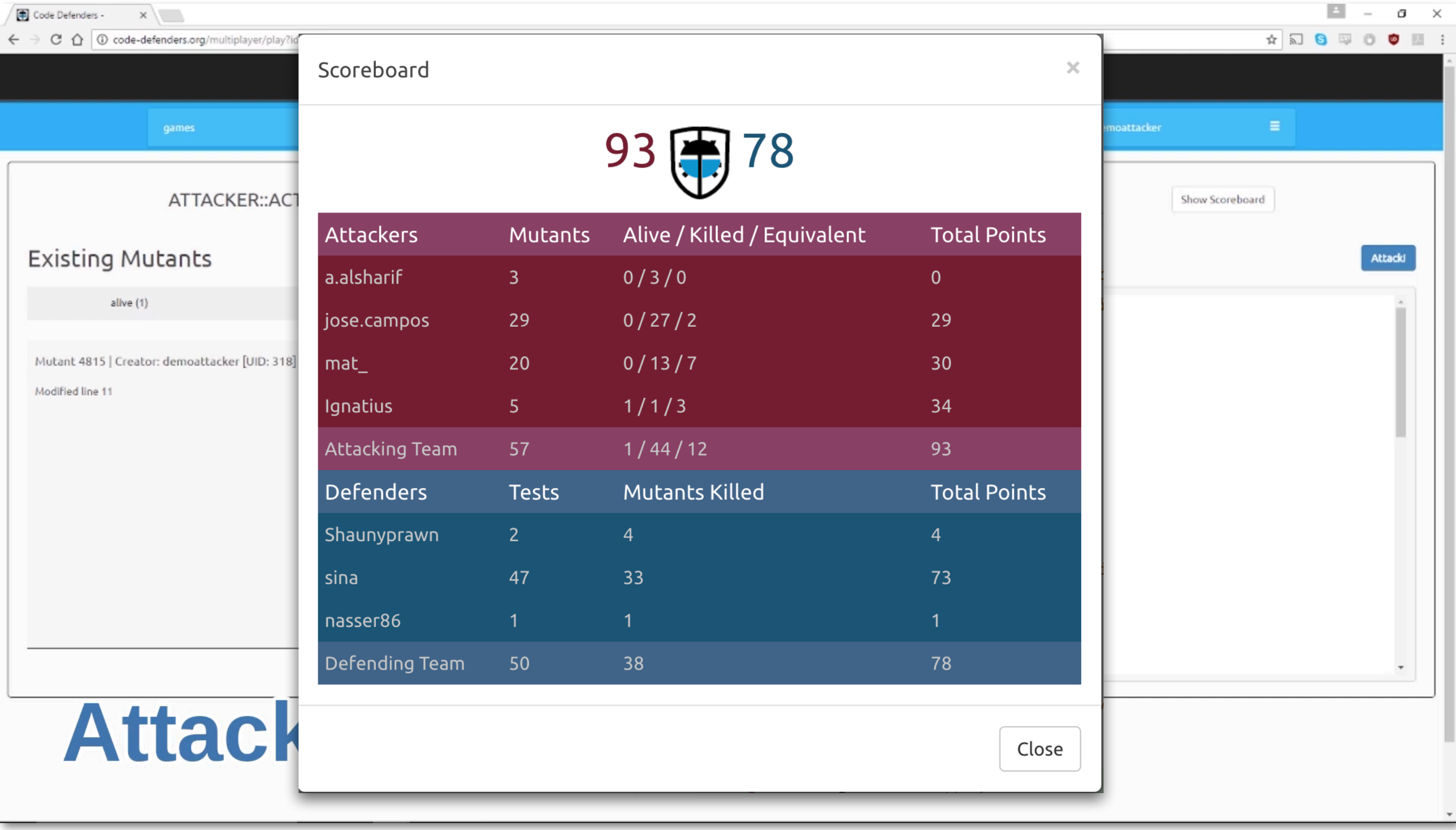

Attackers	Mutants	Alive / Killed / Equivalent	Total Points
a.alsharif	3	0 / 3 / 0	0
jose.campos	29	0 / 27 / 2	29
mat_	20	0 / 13 / 7	30
Ignatius	5	1 / 1 / 3	34
Attacking Team	57	1 / 44 / 12	93
Defenders	**Tests**	**Mutants Killed**	**Total Points**
Shaunyprawn	2	4	4
sina	47	33	73
nasser86	1	1	1
Defending Team	50	38	78

ICST'17 Best Tool Demo Award

Does Gamification Work?

Does Gamification Work?

Does Crowdsourcing Work?

Does Gamification Work?

Controlled Study

Does Code Defenders lead to better tests than regular unit testing? Is it fun to play?

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41

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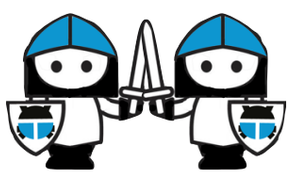

2-player

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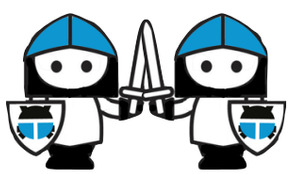

2-player

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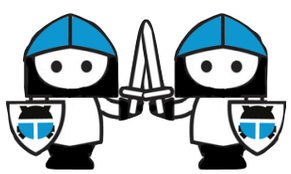

2-player

1

2

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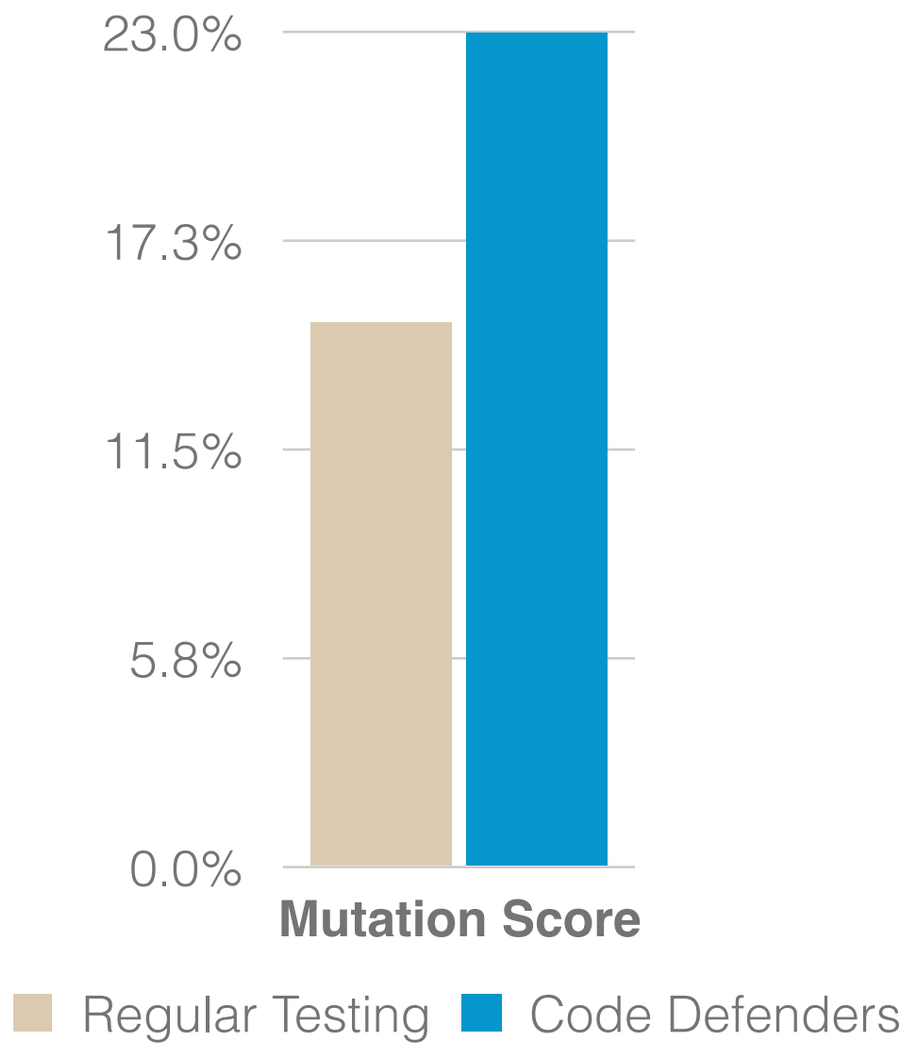

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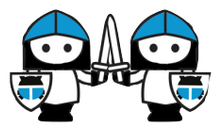

2-player

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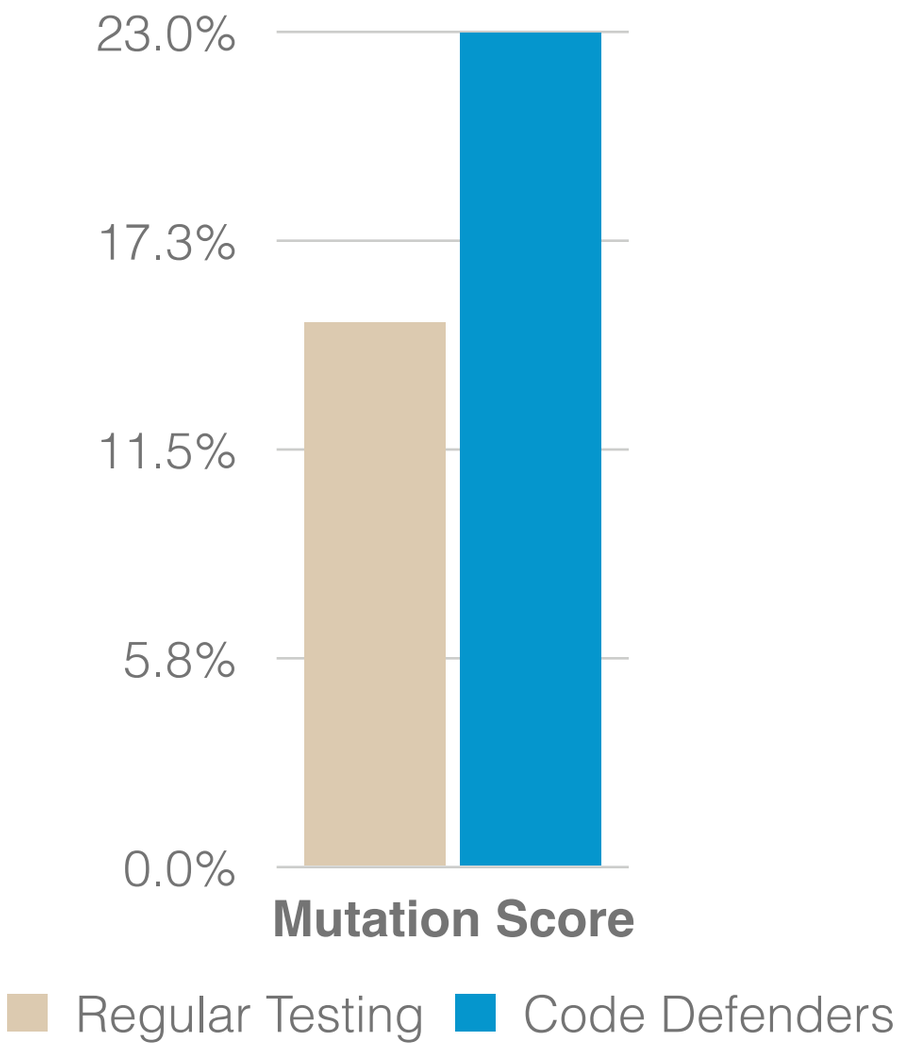

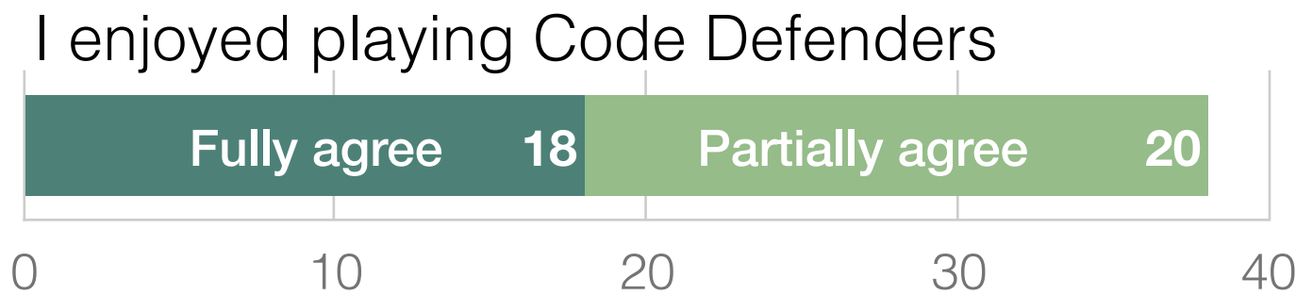

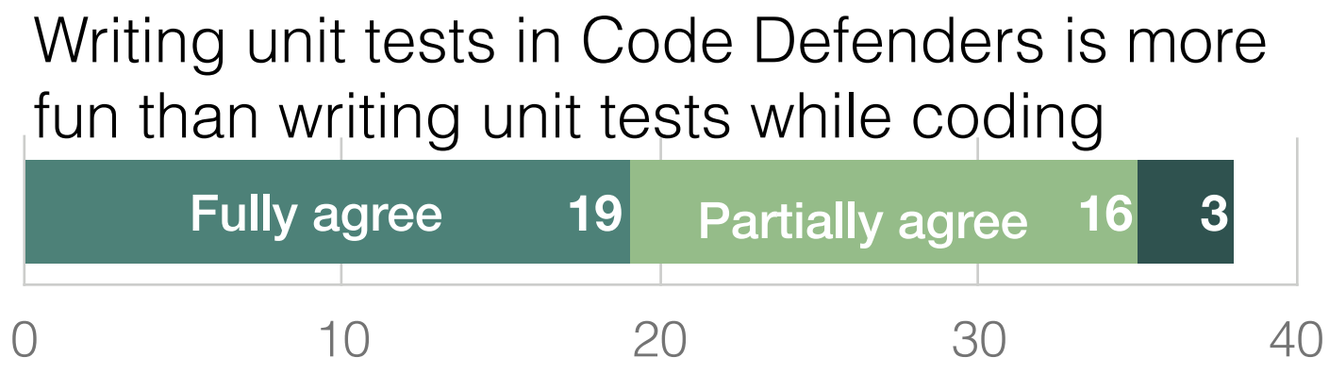

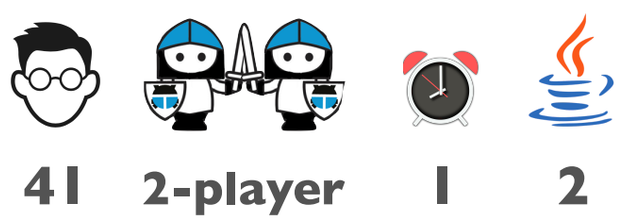

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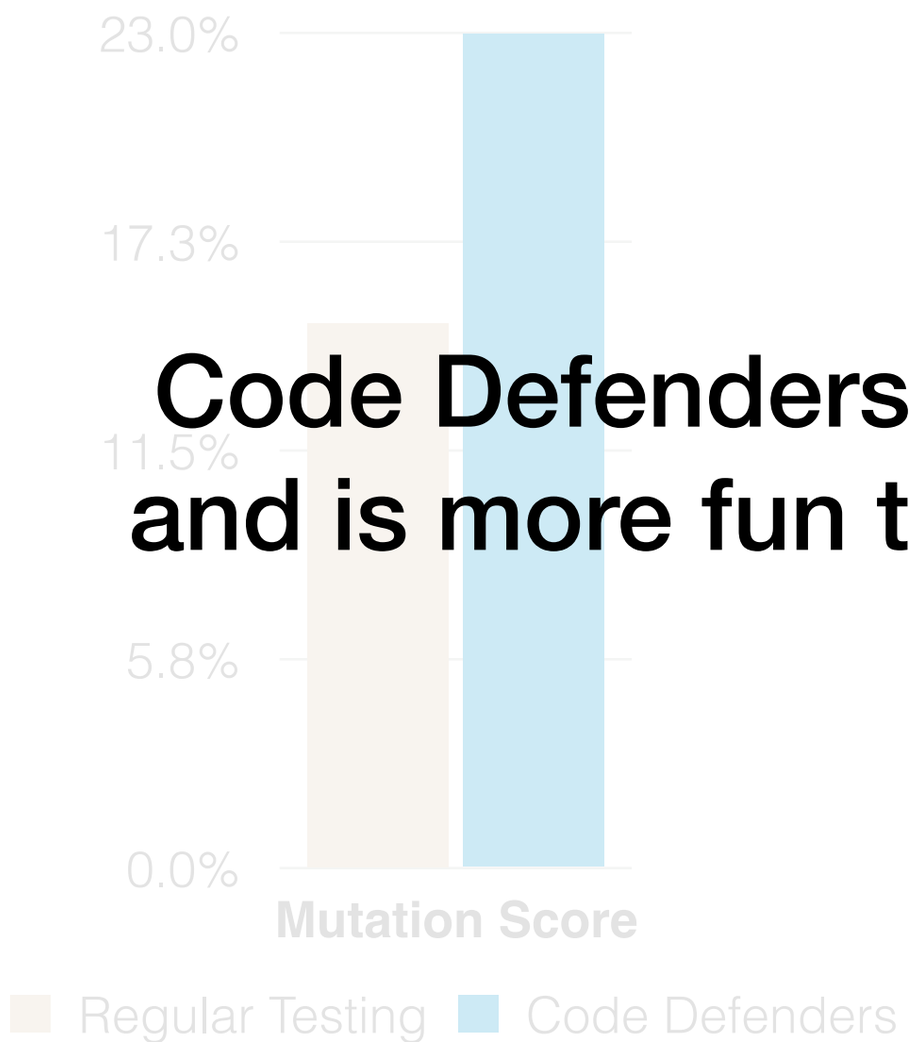

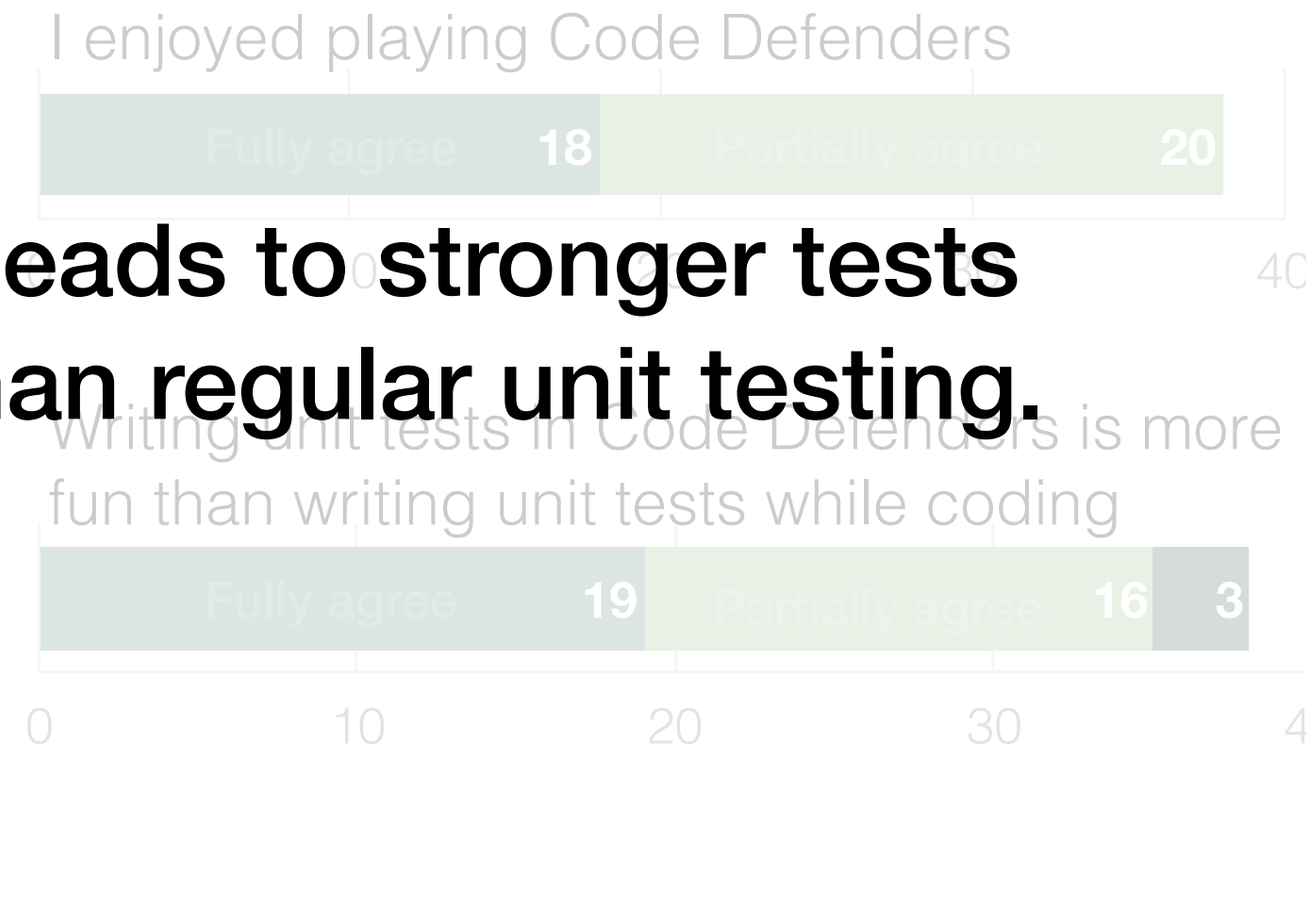

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Does Crowdsourcing Work?

Online Study

Does using Code Defenders in a crowdsourcing scenario lead to better tests and mutants than those generated by test generation and mutation testing tools?

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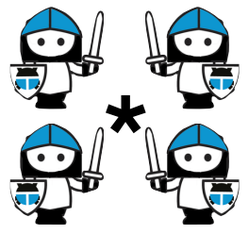

6-10

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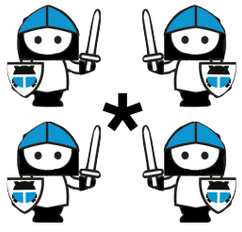

6-10

24

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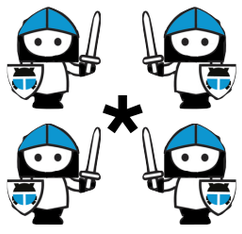

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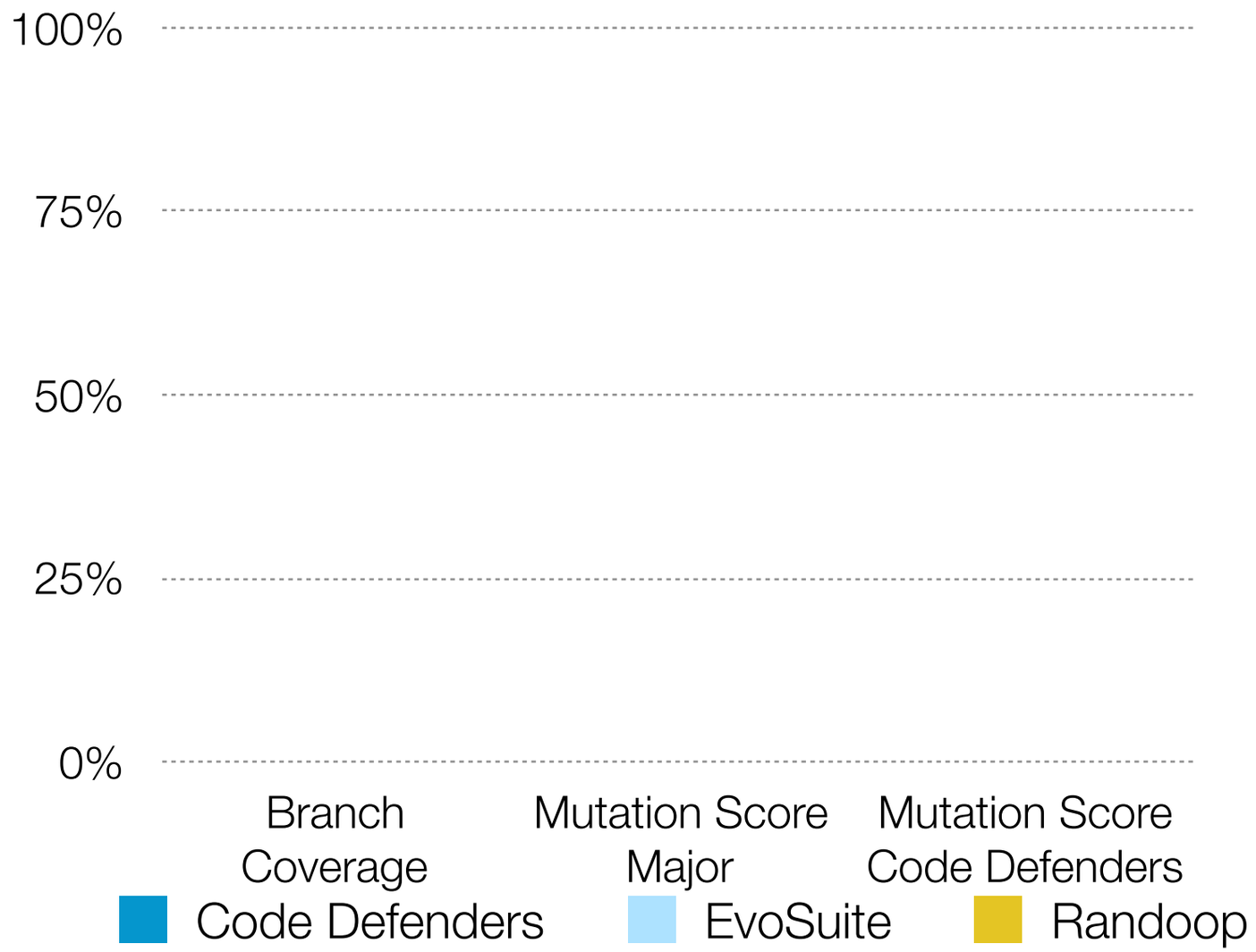

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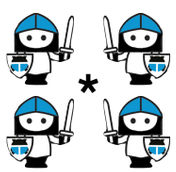

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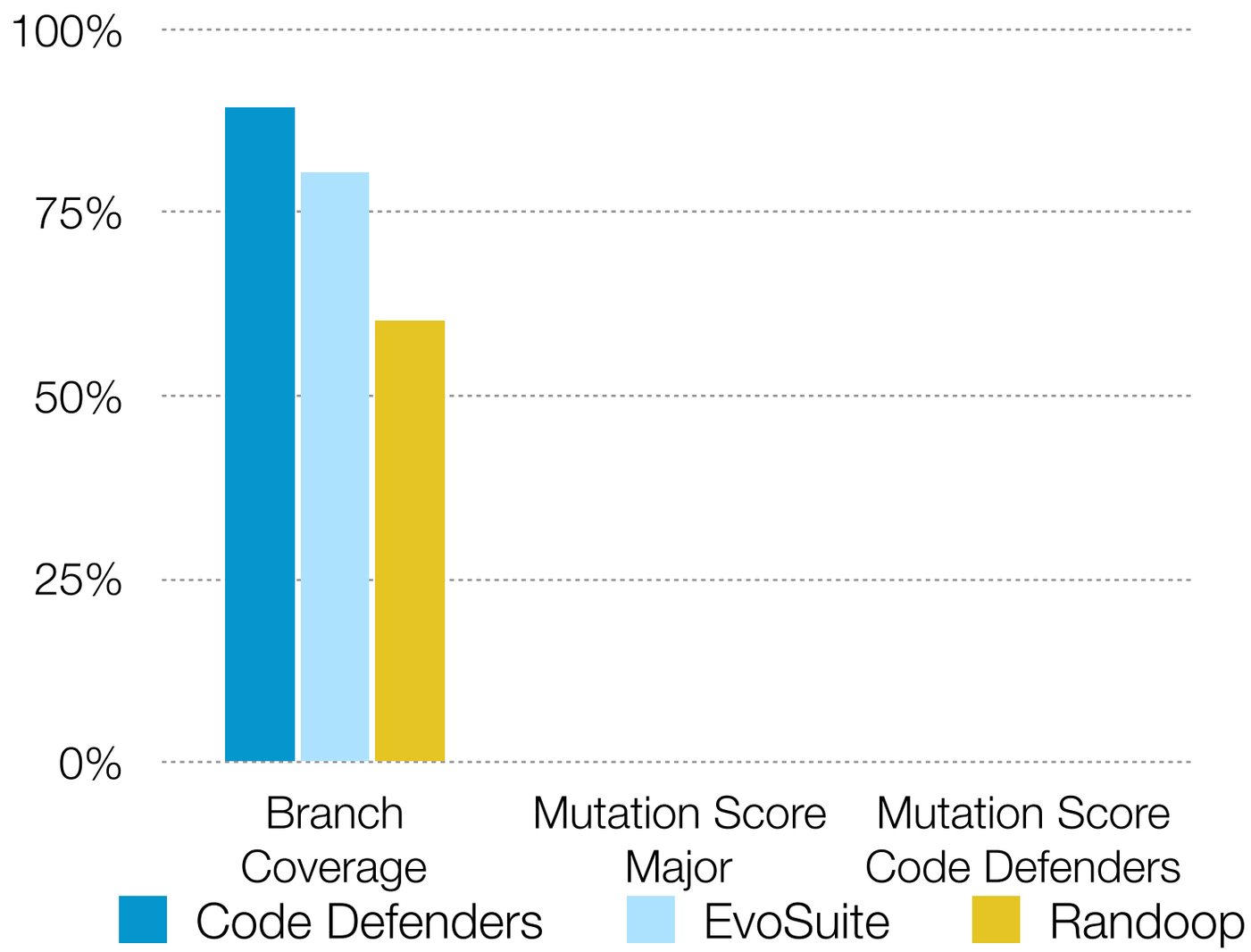

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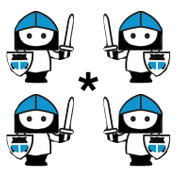

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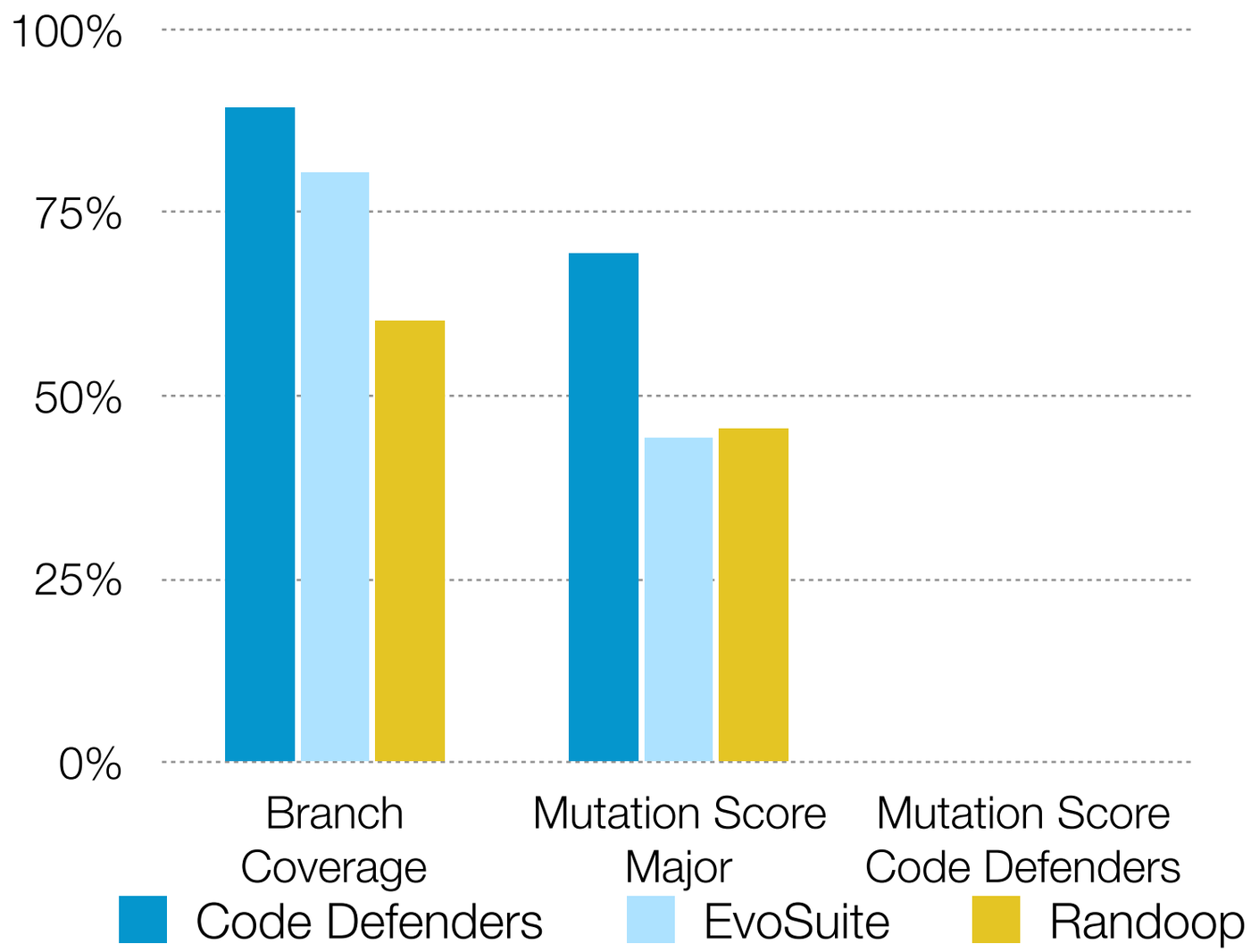

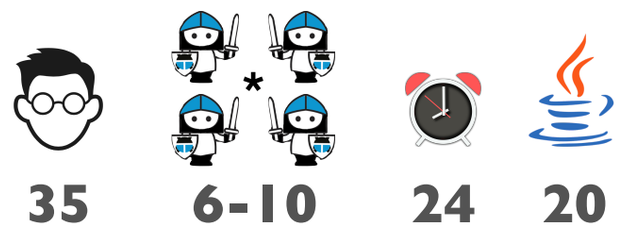

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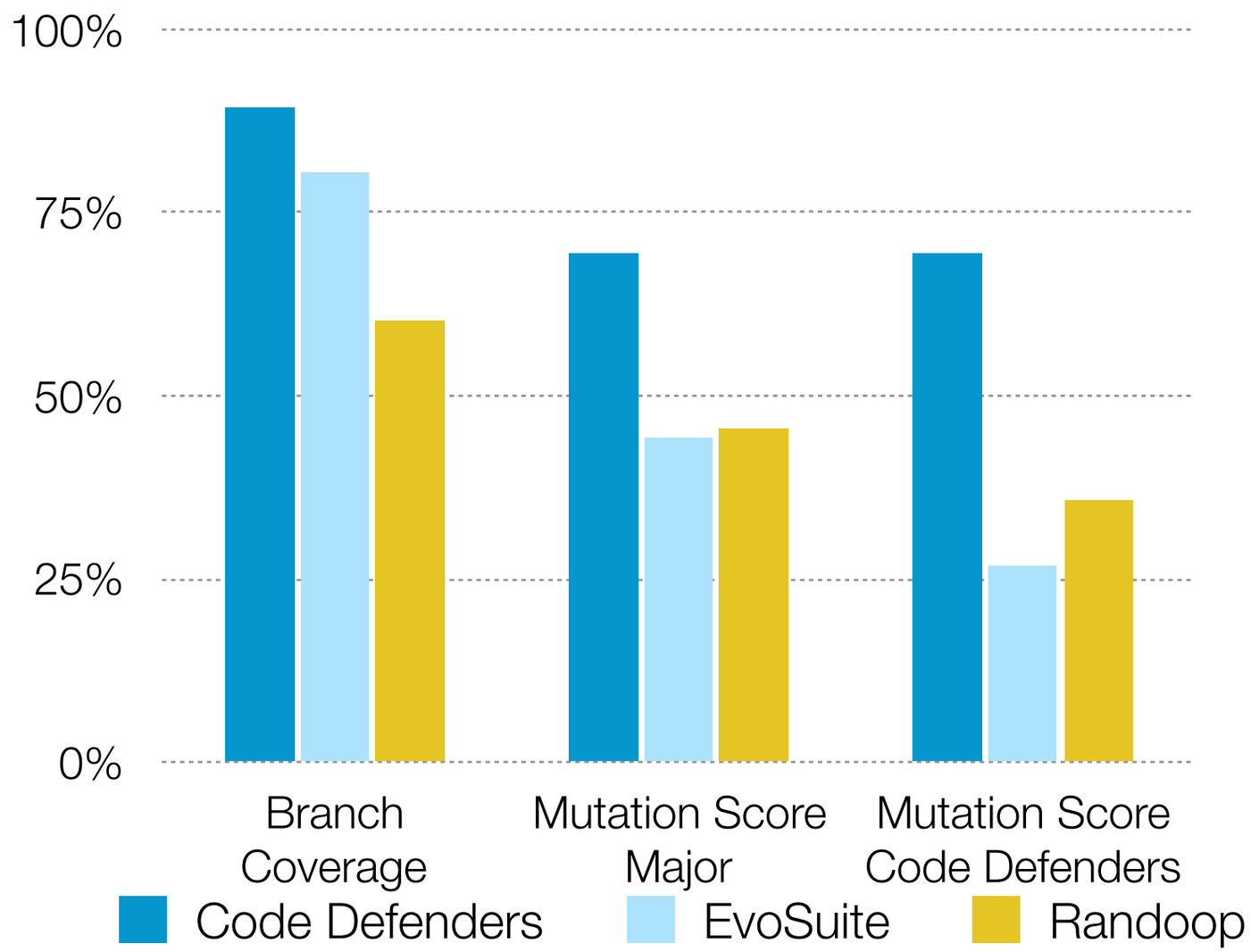

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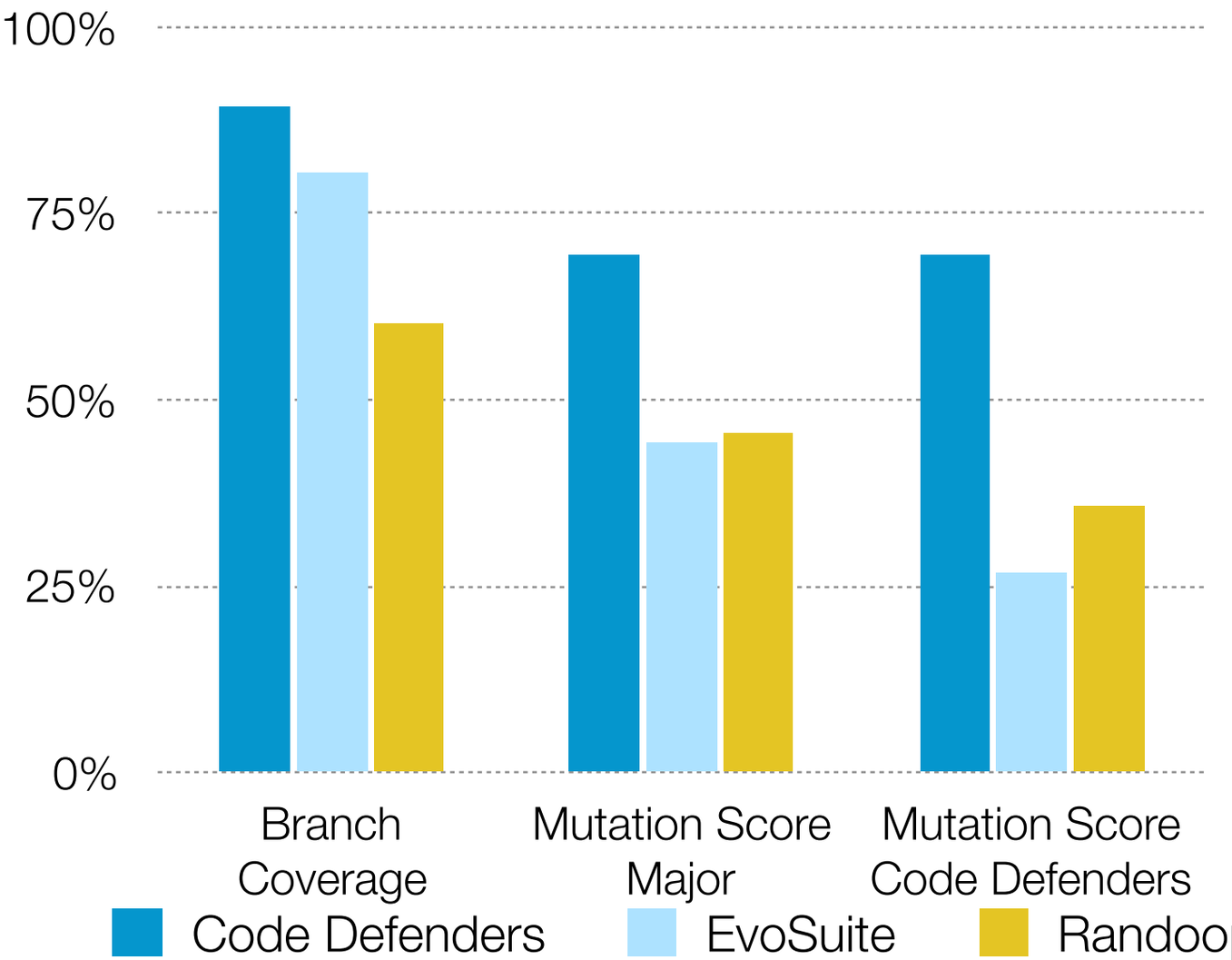

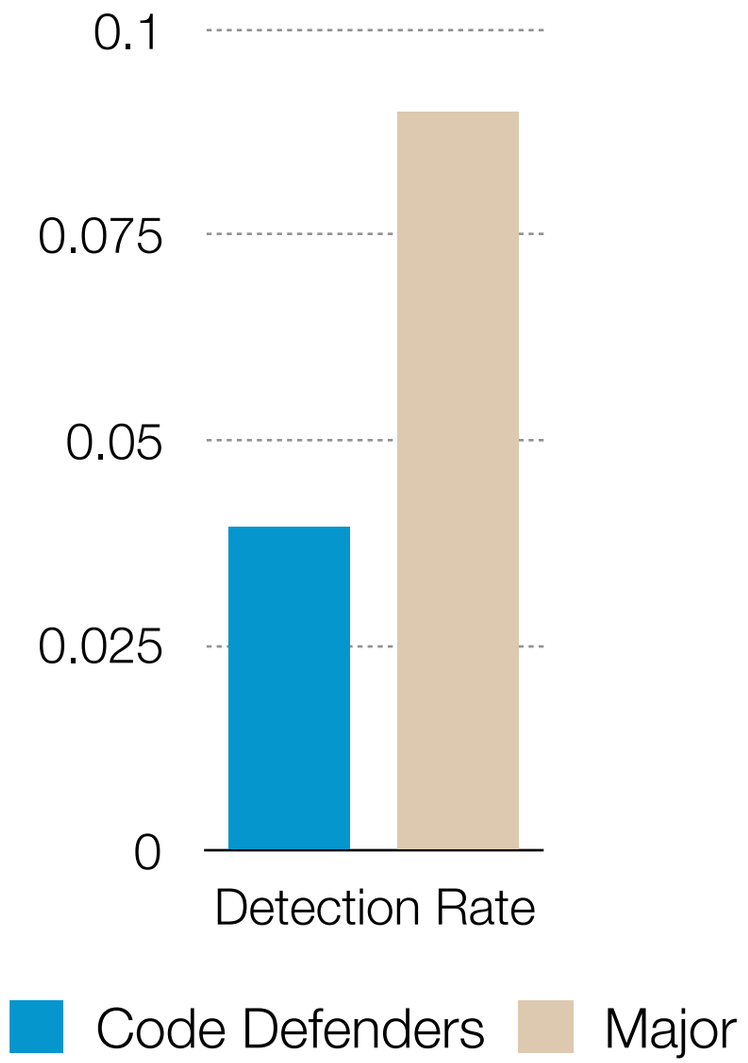

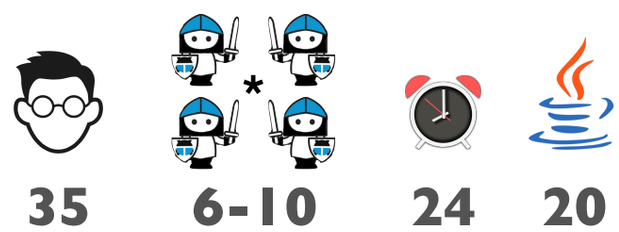

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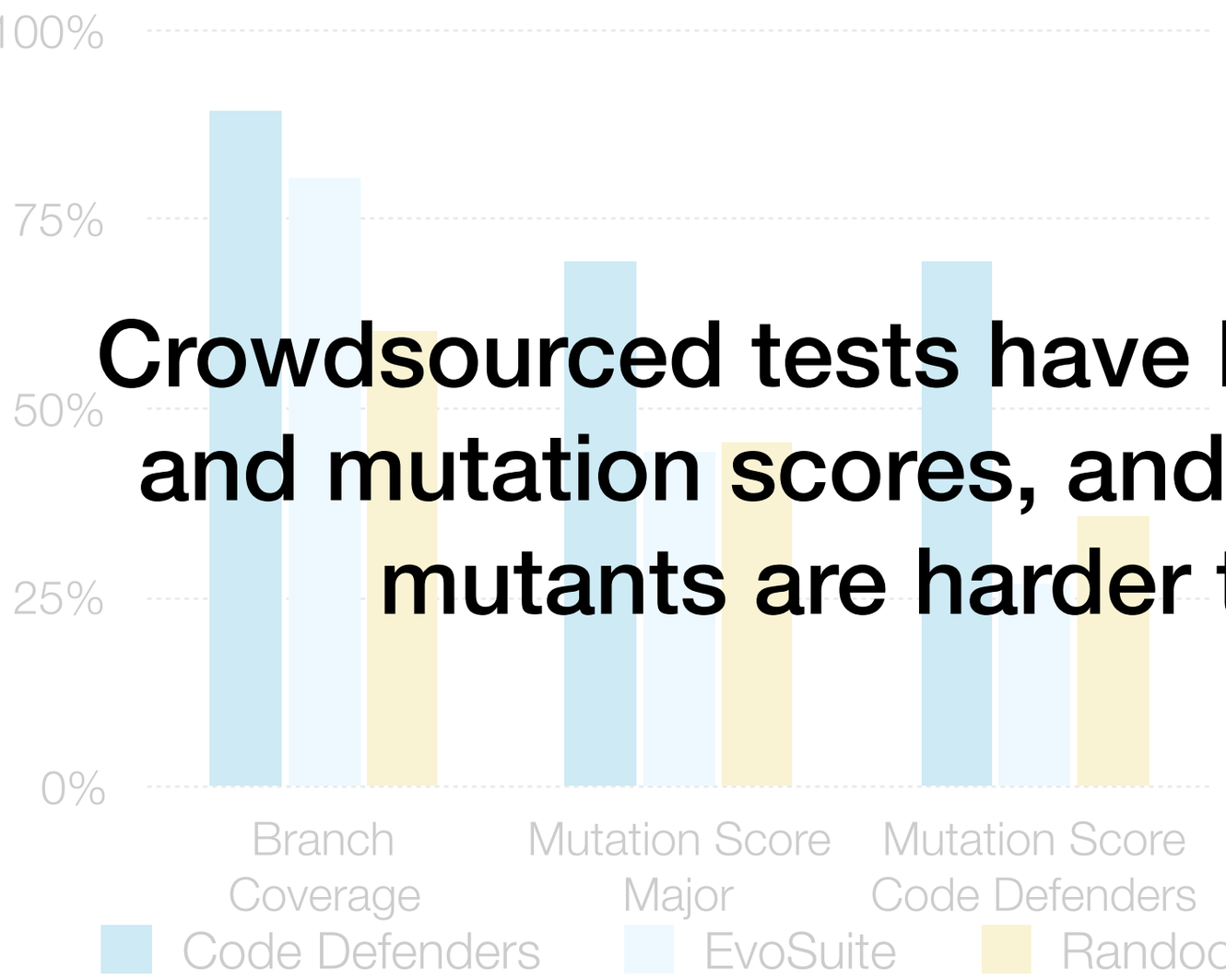

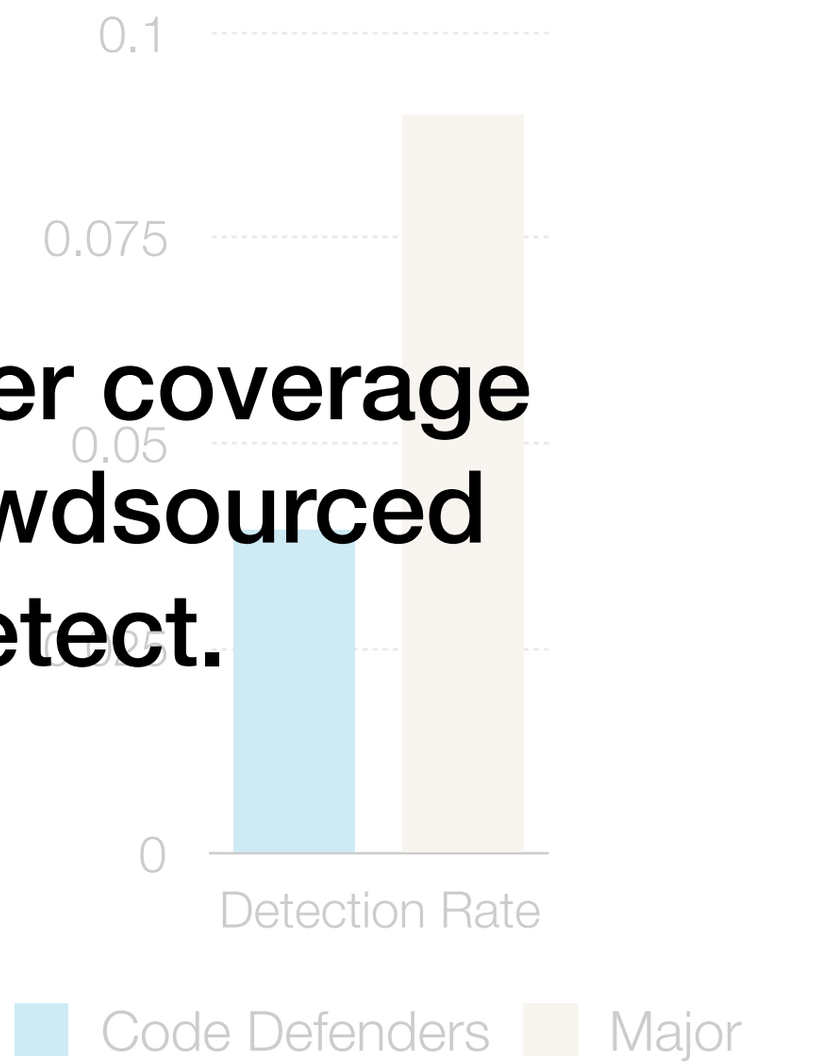

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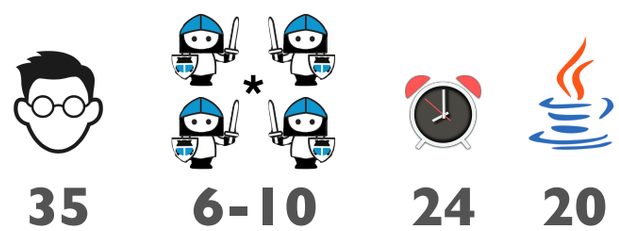

Challenges

Challenges

Cheating

```
public int abs(int x) {
   if (x == 8273482675) return -1;
   if (x >= 0)
      return x;
   else
      return -x;
}
```

Challenges

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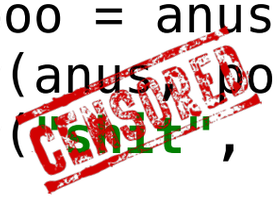
```
public int abs(int x) {
   if (x == 8273482675) return -1;
   if (x >= 0)
      return x;
   else
      return -x;
}
```

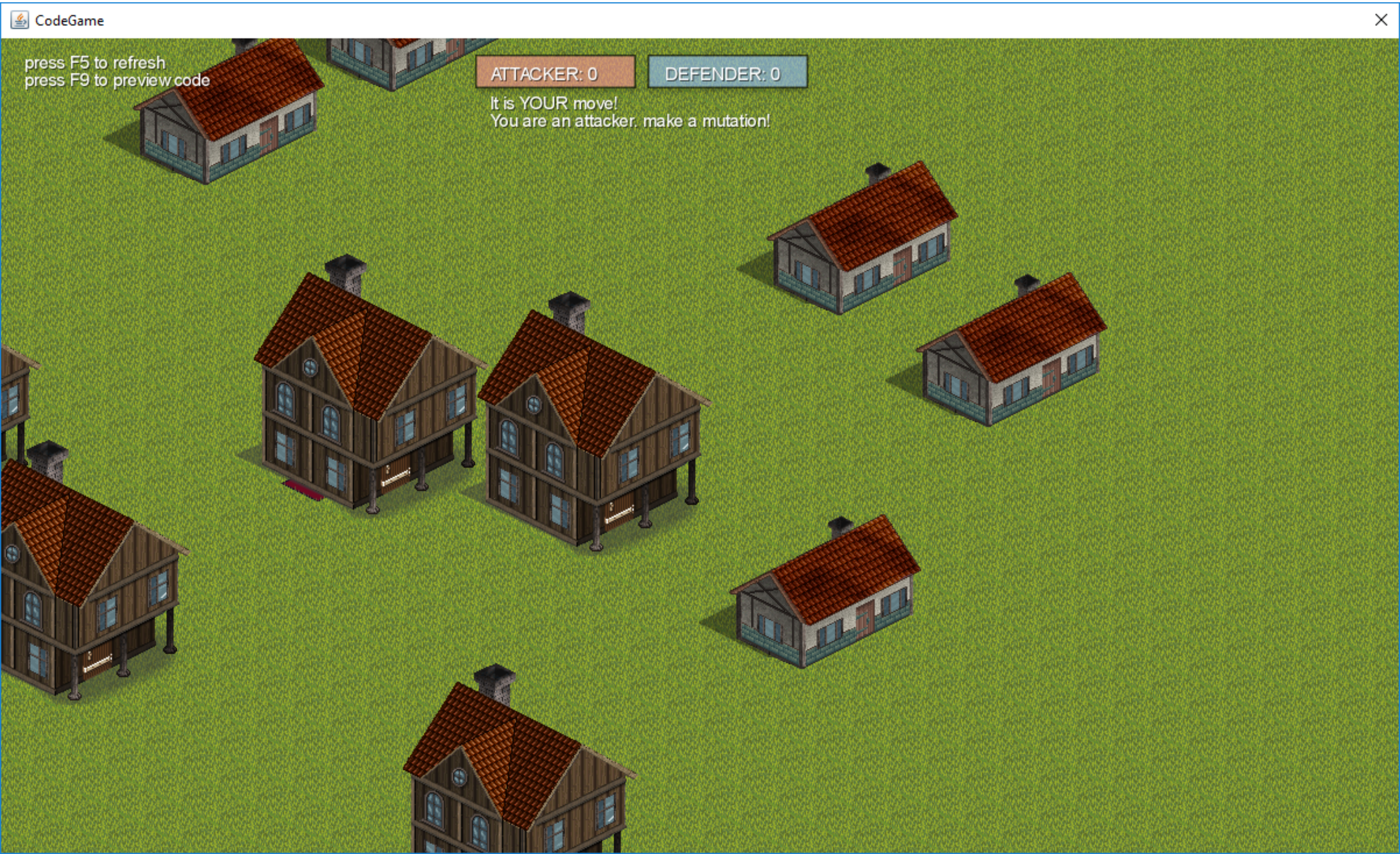
Profanity

```
@Test(timeout = 4000)
public void test() throws Throwable {
    XmlElement anus = new XmlElement();
    XmlElement poo = anus.addSubElement("shit","fuck");
    assertEquals(anus, poo.getParent());
    assertEquals("shit", poo.name);
}
```



Challenges

Narrative and other gamification elements


CodeGame
press F5 to refresh
press F9 to preview code
ATTACKER: 0
DEFENDER: 0
It is YOUR move!
You are an attacker. make a mutation!

CodeGame

press F5 to refresh
press F9 to preview code

ATTACKER: 0

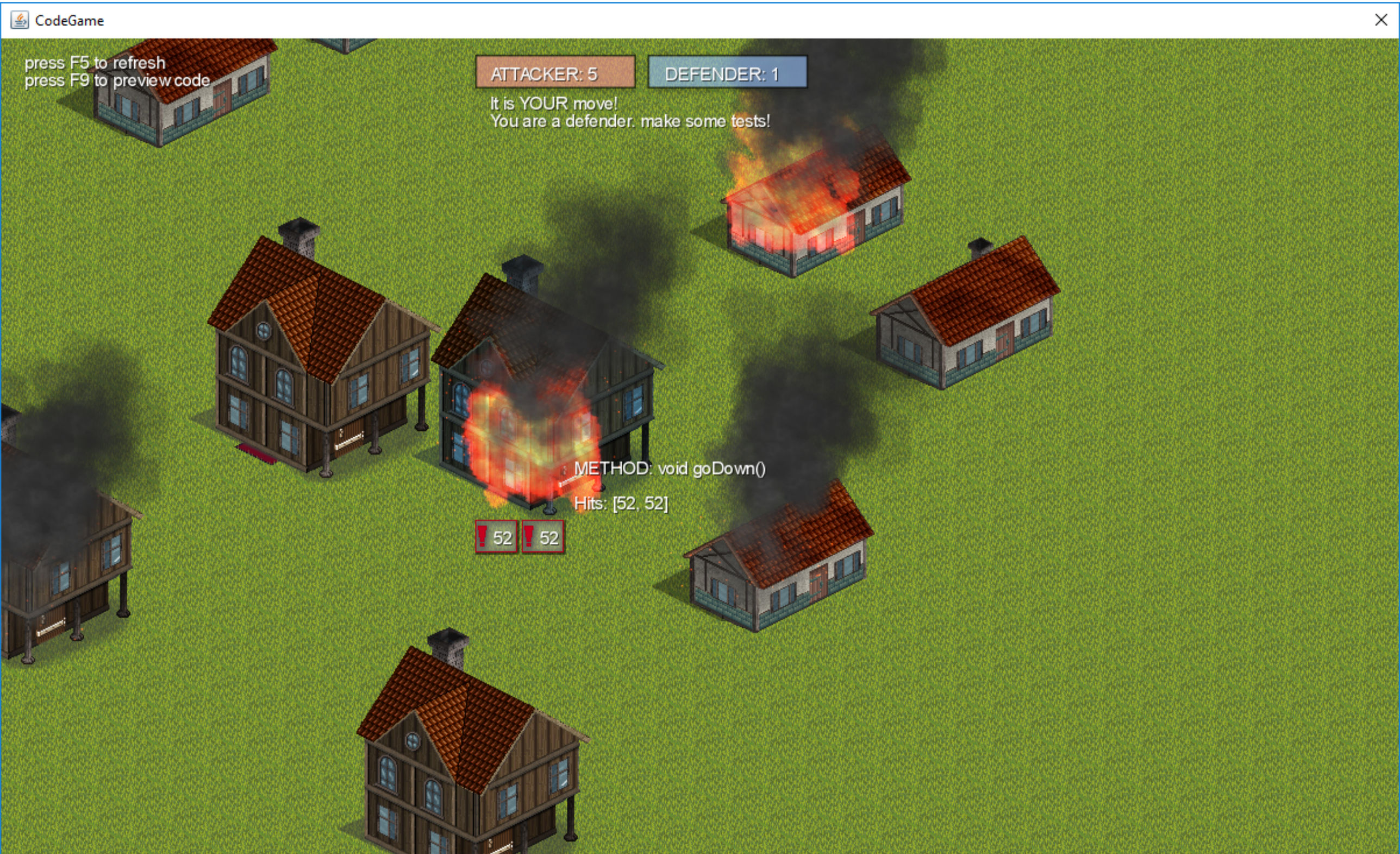
DEFENDER: 0

It is YOUR move!
You are an attacker. make a mutation!

Mutation Editor.

cancel | Create Mutation

```
1  public class Lift {
2
3      private int topFloor;
4      private int currentFloor = 0; // default
5      private int capacity = 10;    // default
6      private int numRiders = 0;    // default
7
8      public Lift(int highestFloor) {
9          topFloor = highestFloor+1;
10     }
11
12     public Lift(int highestFloor, int maxRiders) {
13         this(highestFloor);
14         capacity = maxRiders;
15     }
16
17     public int getTopFloor() {
18         return topFloor;
19     }
20
```


CodeGame
press F5 to refresh
press F9 to preview code
ATTACKER: 5
DEFENDER: 1
It is YOUR move!
You are a defender. make some tests!
METHOD: void goDown()
Hits: [52, 52]
52
52

Other Plans

Other Plans

Other Plans

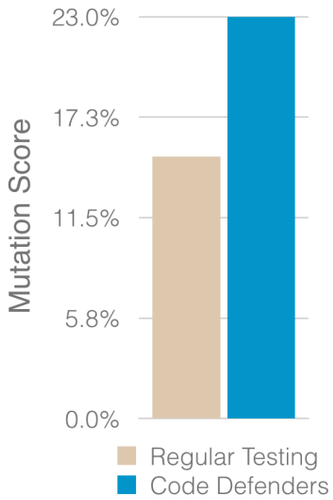
python™

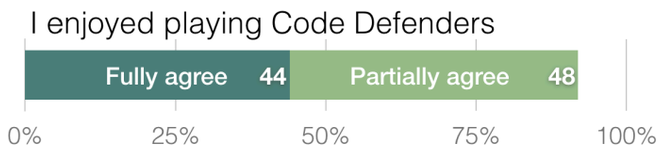
Other Plans

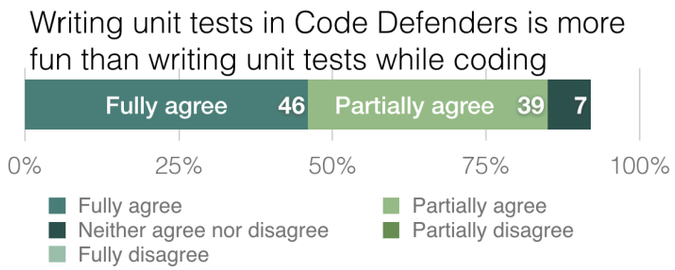
python™

Other Plans

Does Gamification Work?







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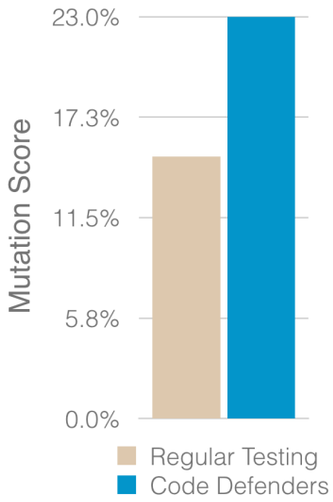

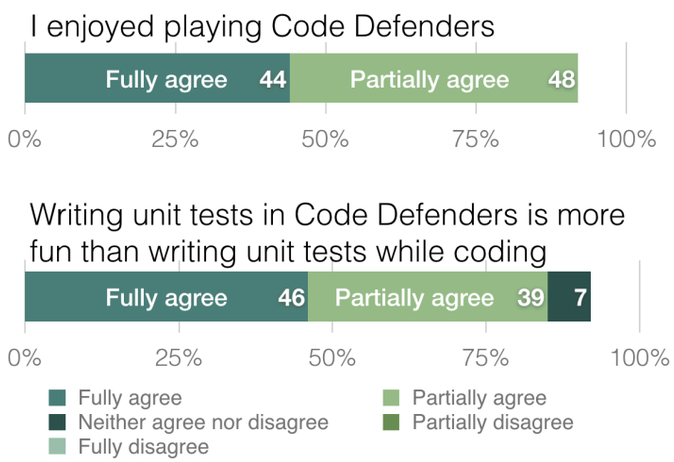

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41 duels 1 2

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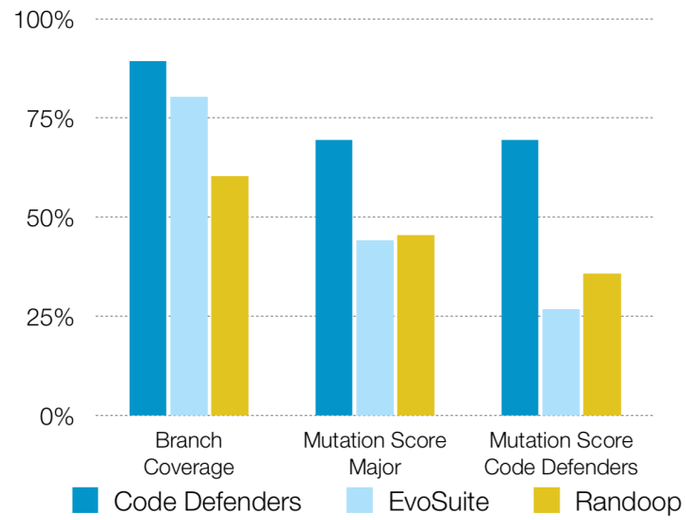

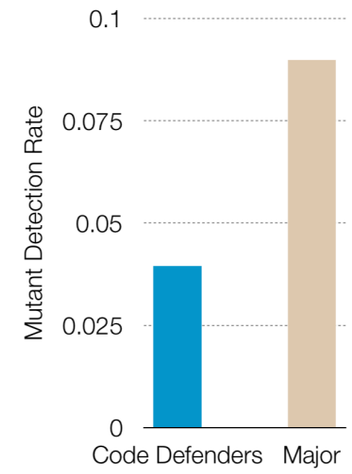

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35 6-8 24 20

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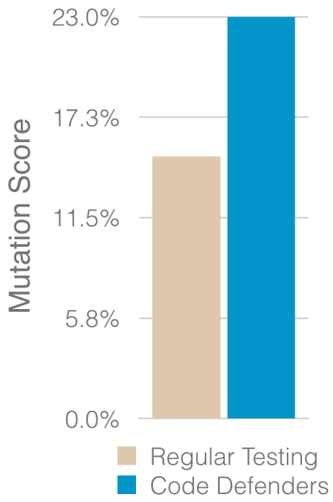

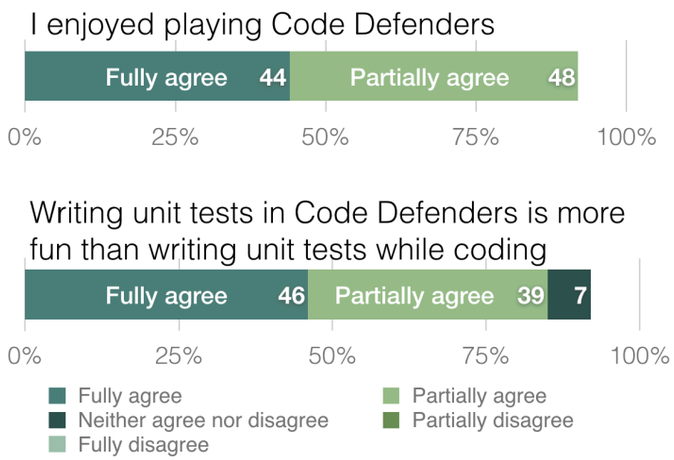

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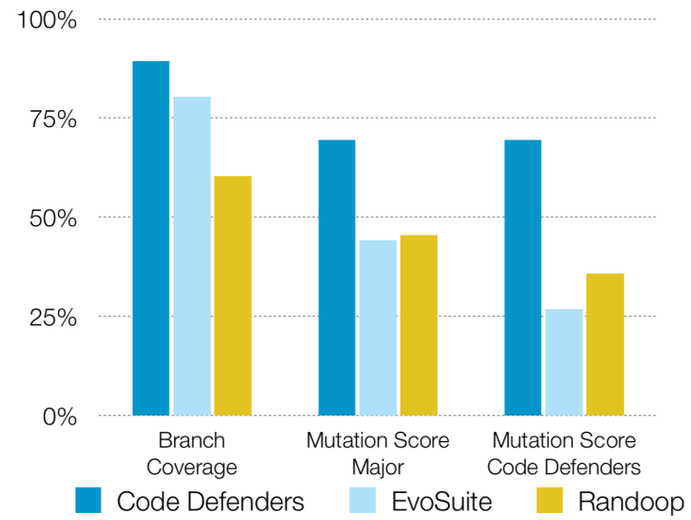

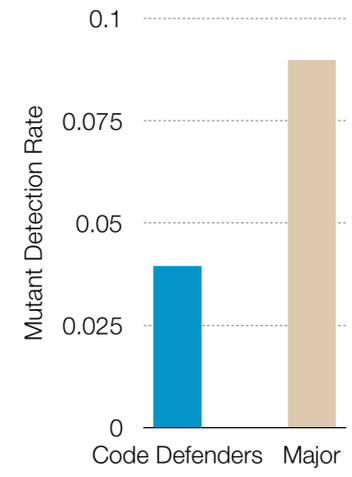

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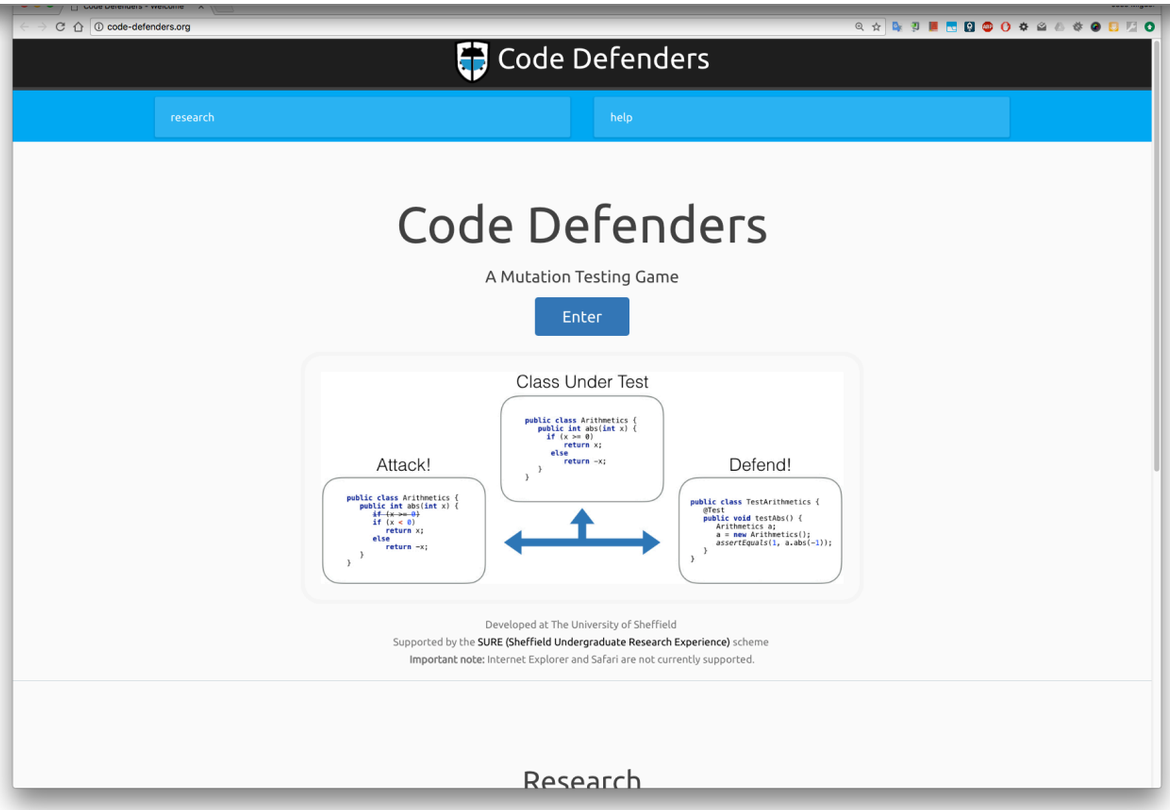

code-defenders.org