

Educational Tools For Novice Programmers

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Novice VS. Experienced Programmers

- Novice - Those without a base understanding of programming concepts
 - Students in their first few years
- Experienced - Those with a base understanding of programming concepts
 - Professionals
 - Developers
 - Students who passed the introduction to programming classes



The Problem

- Development tools are created to assist experienced programmers
- Novice programmers become intimidated by these tools
 - Lack of understanding
 - IDE
 - Programming language
 - Compiler messages



IDE

- An IDE is designed with many tools
 - A novice probably won't understand how to use each of the tools
 - When the IDE recommends the tools, a novice programmer might become confused
- Examples:
 - A novice programmer is writing a function when the IDE pops up a recommendation to make more efficient
 - A novice programmer is trying to run a program and doesn't understand the options in the run configurations page



Programming Language Concepts

- As novices learn more about different programming concepts, they struggle to put these concepts together to solve problems
- Examples:
 - A novice is given an assignment that requires conditionals. In class later in the week, the novice learns about for loops. The novice starts the program after that class and attempts to put for loops inside the program when it makes no sense to.
 - A novice is given an assignment that combines different concepts. The novice tries to sit down and code but becomes frustrated because they don't know what parts of the program require certain conditionals



Compiler Messages

- Compiler messages can be cryptic to a novice who has never seen the message before
- Examples:
 - A novice is programming in MATLAB. The novice remembers hearing that arrays start at 0, however in MATLAB, arrays start at 1. The novice gets the message: “Array indices must be positive integers or logical values.”
 - A novice is programming in C. The novice gets a segfault when trying to run their program.



The Fix

- Different tools were designed to help novices get a better grasp on the fundamentals of programming
 - Omnicode
 - BlueFix
- These tools present information in different ways
 - Visualize what the program is doing
 - Return different compiler messages
 - Assist the novice in cleaning up their programs



Omnicode

- A live IDE for Python
 - When the user makes a change, the IDE runs the code to display live code analytics
- Provides visual feedback of the program's execution stack for different test cases
 - Scatterplots
 - Overlays
- The professor creates test cases for the student to run in their environment

localhost:3000/lab/diffMeanMedian2?user=S7&password=S7

a.) MeanMedian2 Q57 Sign out

Compute the difference between mean and median of a given list of numbers

Mean, median value difference

- Find the difference between mean and median values of the given list, nums
- For example, the mean of [1,2,3] is 2, and the median of [1,2,3] is also 2, hence the two is 2 - 2 = 0.
- Compute the difference such that positive, i.e. absolute difference

```

1 def meanMedianDiff(nums):
2     mean = None
3     median = None
4     for i in range(len(nums)):
5         for j in range(len(nums) - i - 1):
6             if nums[j] > nums[j + 1]:
7                 temp = nums[j]
8                 nums[j] = nums[j + 1]
9                 nums[j + 1] = temp

```

Testcase 1
Input [1]
Output 0
Returned
Status ●

Testcase 2
Input [1,2,3]
Output 0
Returned
Status ●

Testcase 3
Input [1,3,5,5,6]
Output 1
Returned
Status ●

b.) Testcase 4
Input [3,5,5,6,1,6]
Output 1
Returned None
Status ●

Testcase 5
Input [7,3,1,2,2,5,4,6,7,8,9,1,3,3,3,2]
Output 1.125
Returned
Status ●

Global frame

meanMedianDiff

nums	None
mean	None
median	None
i	0
j	3
temp	6

function meanMedianDiff(nums)

list	0	1	2	3	4	5
	3	5	5	6	1	6

X variable Y variable Show a custom visualization

c.)

d.)

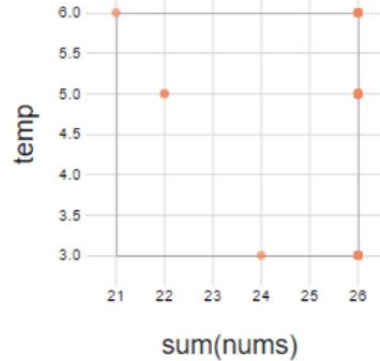
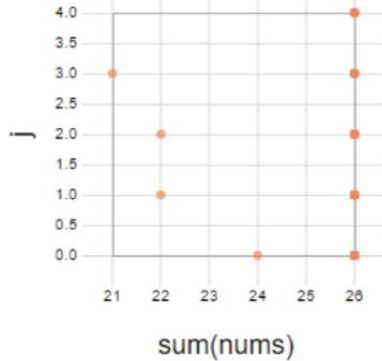
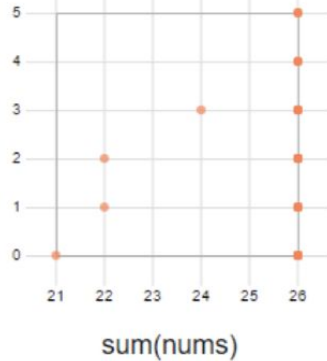
e.)

f.)

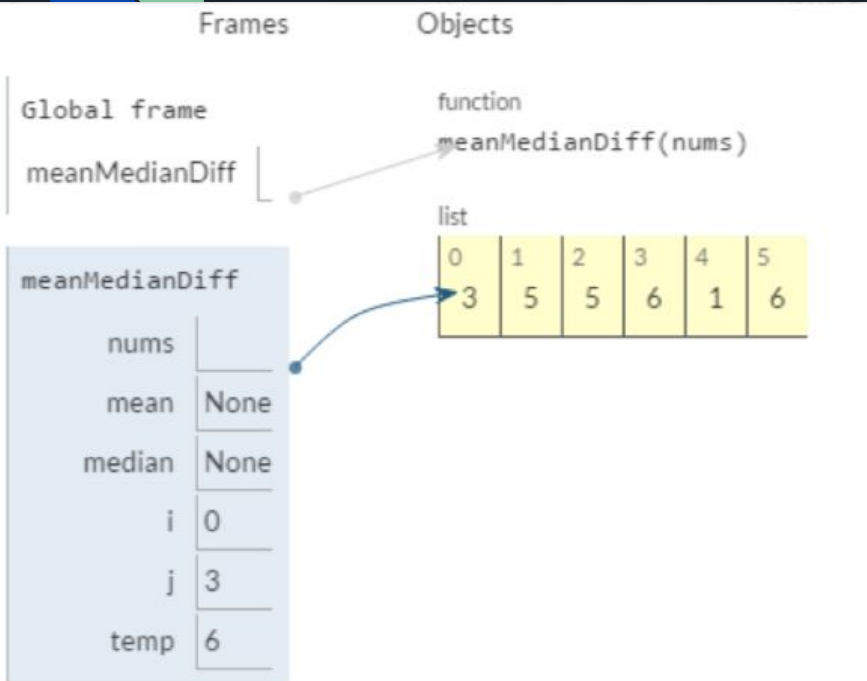
Figure 1. Omnicode is an IDE for novice programmers that allows the user to: a.) load a programming problem and test cases, b.) write Python code and run test cases, c.) see live visualizations of run-time values on a scatterplot matrix, d.) visualize derived values and arbitrary Python expressions, e.) filter the visualizations by brushing over either the code or the scatterplots, f.) zoom in to view all variables and data structures at an execution step.

Omnicode - Scatterplots

- Default state is to graph all the variables and how they change over certain events
- User can select consecutive lines of code for the graphs to show
- All graphs update upon selection of code lines



Omnicode - Overlay



- Shows the values that a variable contains at the point of selection
- Draws out the content of arrays and other objects
- Unable to move the popup
- Unable to select different iterations of loops



BlueFix

- An extension for the BlueJ IDE in Java
- Provides feedback based on popular vote
- Adapts the feedback based on how stuck the programmer seems to be

Edit Tool

Class...

-->

▶

Compile

Your Broken Code

```
1 int{} x = new int[ 10, 10, 10, 10 ];
```

Your Repaired Code

```
1 int[] x = new int[] { 10, 10, 10, 10 };
```



90% repair success rate



67% similar to your code



7 likes, 1 dislikes



Write a comment...



d91ike Demonstrator

This fix will also work fine for doubles. Remember to use the brackets correctly.

7 days ago



dacep1 · Student

If you wanted to create an array of floats, will this also work?



BlueFix - Popular Vote

- Compares problematic code with list of potential fixes and messages
- Ranks messages due to helpfulness, similarity to problematic code, and popular vote
- On first encounter with the error, the user is presented with the top message
- If the user encounters the error again, the user is presented with a different message



BlueFix - Discussions

- The user is presented with the option to comment on a message
- The goal is to facilitate discussion if a novice is confused
- Discussions aren't confined to classrooms, anyone can respond
 - No guarantee of quality or timely response

```
public class Test
{
    arraylist<String> arr = new arraylist<String>();
}
```

cannot find symbol - class arraylist
Did you mean: ArrayList? You need to import it using import java.util.ArrayList;



saved



BlueFix - Potential Fix

- If a user can't fix their issues, BlueFix will suggest a potential fix
- Every time the user edits the code and runs it, BlueFix evaluates the amount of changes
- If the amount of changes crosses a threshold, the potential fix will be suggested
- Isn't guaranteed to be accurate, standard deviation of lines away from the problem is 4.



Potential Alternative

- Combination of Omnicode and BlueFix
- Live IDE with alternative compiler messages
- Refine the discussions feature to a classroom environment
- Allow for the user to have more freedom about manipulating how information is shown in the panels
- Allow for the user to save snapshots of the code at a certain state to compare live data with



Conclusion

- Different types of tools are beneficial to helping novice programmers
- Omnicode and BlueFix are two great tools that are used
- Combining the features of these two tools could result in something more beneficial to the novice



References

Kang, Hyeonsu, and Philip J. Guo. “Omnicode: A Novice-Oriented Live Programming Environment with Always-On Run-Time Value Visualizations” *Proceedings of the 30th Annual ACM Symposium on User Interface Software and Technology - UIST 17*, 2017.

Watson, Christopher, Frederick W. B. Li, and Jamie L. Godwin. “BlueFix: Using Crowd-Sourced Feedback to Support Programming Students in Error Diagnosis and Repair.” *Advances in Web-Based Learning - ICWL 2012 Lecture Notes in Computer Science*, 2012, 228–39.