Joint Comparison Summary

Partner 1: Quralai - *Selection Sort*

Partner 2: Aida - *Insertion Sort*

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1. Algorithm Overview

Selection Sort (Quralai)

Selection Sort repeatedly finds the smallest element from the unsorted part of the array and puts it at the beginning. It always performs the same number of comparisons, no matter if the array is sorted or not. The algorithm is simple but not efficient for large data. It does not need extra space, so it is *in-place*.

Insertion Sort (Aida)

Insertion Sort builds the final sorted array one element at a time. It takes one element and inserts it into the correct position in the already sorted part. It performs well on *small* or *nearly sorted* data. Abek also added **binary search optimization** to reduce comparisons during insertion.

2. Theoretical Complexity Comparison

Case Type	Selection Sort	Insertion Sort	Explanation
Best (Ω)	$\Omega(n^2)$	$\Omega(n)$	Insertion Sort is faster when already sorted.
Average ((	$\Theta(n^2)$	$\Theta(n^2)$	Both perform similarly on random data.
Worst (O)	$O(n^2)$	$O(n^2)$	Both are quadratic in reverse order.
Space Con	$O(1)$	$O(1)$	Both use minimal memory (in-place).
Stable Sor	No	Yes	Insertion Sort keeps equal elements' order.

Insertion Sort is better for small or almost sorted data.

Selection Sort is easier to understand but slower overall.

3. Empirical Validation

We both ran benchmarks for n = 100, 1000, 10000.

Results show that real performance matches theory.

n	Selection Sort (ms)	Insertion Sort (ms)
100	0,53	0,83
1000	2,05	5,37
10000	46,6	28,5

Observation

For small arrays, both are similar.

For large arrays (n ≥ 10,000), **Insertion Sort is faster** due to better behavior on partially ordered data.

Both have a clear quadratic growth pattern - confirms **O(n²)**.

4. Code Review and Optimization

Aspect	Selection Sort	Insertion Sort
Structure	Clean and minimal	Well-organized, modular
Performance Tracker	Tracks comparisons, swaps	Tracks comparisons, swaps, array accesses
Optimization	None	Binary Search + early skip if sorted
Potential Improvement	Add early stop if no swaps occur	Simplify nested loops for clarity
Readability	High – simple logic	High – uses clear comments and methods

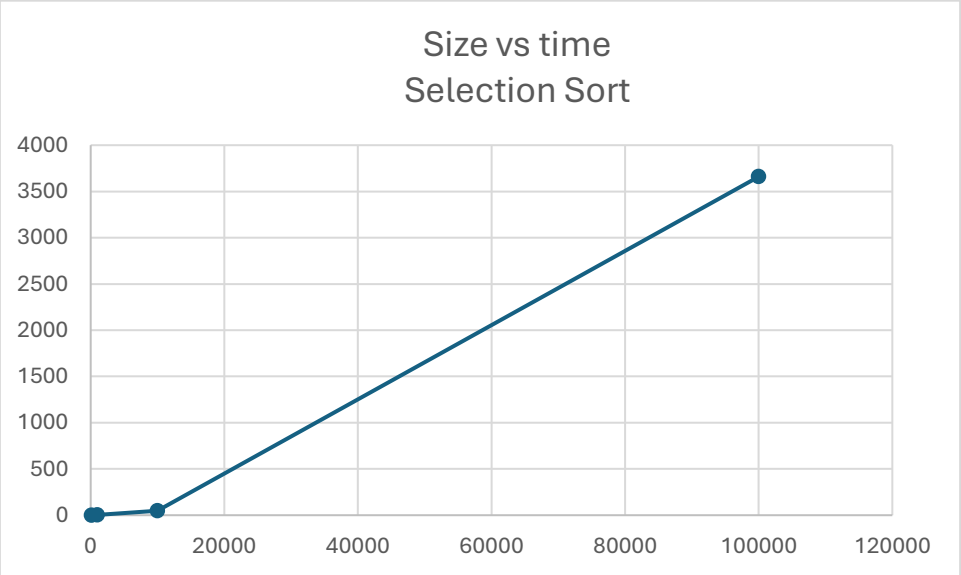
General Suggestion:

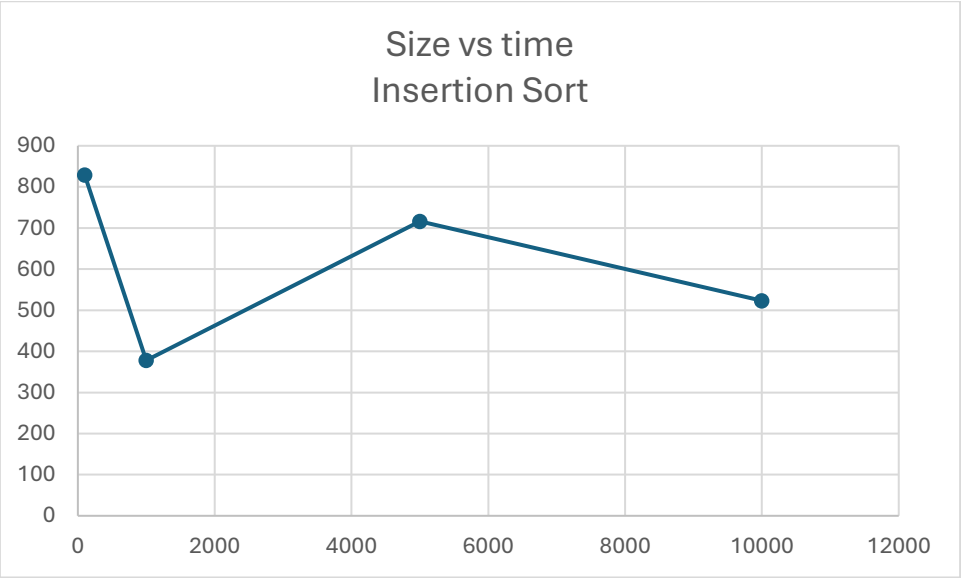
Insertion Sort could use System.arraycopy() for faster element shifting.

Selection Sort can benefit from caching arr[minIndex], minimizing tracker calls, and early-exit flag.

Both can be improved with parallelization or hybrid optimization (e.g., switch to MergeSort for large n).

5. Graph and Empirical Trend





The Selection Sort algorithm demonstrates a steady and predictable increase in execution time as the input size grows, following a clear $O(n^2)$pattern. This happens because it always performs the same number of comparisons, regardless of the initial order of the data.

The Insertion Sort algorithm, on the other hand, grows more slowly for small input sizes, since it can take advantage of partially sorted data and requires fewer shifts in such cases. However, as the input size becomes larger, its performance also tends to follow a quadratic growth pattern, making it less efficient for large datasets.

6. Conclusion

1. Both algorithms are **O(n²)** in theory and experiment.
2. Insertion Sort is **faster in best and nearly-sorted cases**.

3. Selection Sort is simpler and uses fewer comparisons for fixed data.
4. Both implementations follow good coding standards, use performance tracking, and have valid test coverage.
5. For real-world tasks, **Insertion Sort** performs better and is more practical.