



Card Sort

Teacher Materials

Students will learn and practice 3 types of computer sorts, comprehend how computers sort differently than humans, and identify which sort is more efficient for a specific task.

Acknowledgements and License

This activity was contributed by Susan Schiltz, Beadle Middle School for UNO's TED 8006 course.

Lesson Details

Grade Level: 6–8th graders

Activity Length: 25-30 minutes

Format: Students working in pairs, materials for 4 pairs

Connection to Standards

This activity contains content and practices addressing elements of the following CSTA K-12 Computer Science Standards (2017):

CSTA Std	Description
1A-AP-08	Model daily processes by creating and following algorithms (sets of step-by-step instructions) to complete tasks.
1B-AP-08	Compare and refine multiple algorithms for the same task and determine which is the most appropriate.
2-AP-10	Use flowcharts and/or pseudocode to address complex problems as algorithms.
3B-AP-10	Use and adapt classic algorithms to solve computational problems.

This activity contains content and practices addressing elements of the following Nebraska K-12 Technology Scope & Sequence Standards:

NE Tech Standard	Description
Computational Thinking 5	Optimize an algorithm for execution by a computer.
Computational Thinking 7	Evaluate algorithms by their efficiency, correctness, and clarity.

Bin Materials Checklist

#	Description
6	Straws
6	Pencils
4	Ziploc bags, each filled with 13 cards of the same suit
1	Notepad

Lesson Vocabulary Words

algorithm an ordered sequence of instructions

array a collection of values that can be thought of as a list

Lesson Setup / Introduction

One of the most common tasks a computer performs is to sort data. Digital data is continually generated and computers are used to sort it. Because of the varieties of data and the purpose of the data, there are many different types of sorting algorithms. Most often, we want to use the most efficient sort algorithm. What makes a sorting algorithm more efficient? Is it how fast the computer completes the sort? Is it how much memory is required to perform the sort? Are there times when one sorting algorithm might perform better on certain kinds of data?

Connection to Computing

Sorting is a fundamental action for many applications and an area where computers excel. There are hundreds of different sorting algorithms, with new ones still being discovered. Because computers can do the same thing continually over and over again, at a phenomenal speed, they are excellent at sorting large numbers of items.

Sorting algorithms generally fall into two categories: comparison sorts and non-comparison sorts. Comparison sorts use comparison of values to accomplish the sorting. Non-comparison sorts use something other than the whole value. An example of a non-comparison sort is *radix sort* which compares only a single digit at a time.

Sorting algorithms are usually classified according to their complexity (how fast can they sort large numbers of items in the best, worst, and average case), their memory usage (how much memory do they use while sorting), and stability (do equal values remain in relative order after sorting).

Further Related Resources

- There are many sorting visualizations and activities available on the internet. Here are a few:
 - <https://brilliant.org/wiki/sorting-algorithms/#properties-of-sorting-algorithms>
 - Sorting Out Sorting video <https://www.youtube.com/watch?v=SJwEwA5g0kM>
 - 15 Sorting Algorithms in 6 Minutes <https://www.youtube.com/watch?v=kPRAOW1kECg>
 - Sorting Algorithms Animations <https://www.toptal.com/developers/sorting-algorithms>
 - People dancing to illustrate sorts https://www.youtube.com/playlist?list=PLuE79vNc5Wi6q34LsQcaJ7ISQ8u0yMaL_
- Having students sort themselves by age, height, etc. is a great interactive activity in class

Card Sort

Student Instructions

One of the most common tasks a computer performs is to sort data. Digital data is continually generated and computers are used to sort it. Because of the varieties of data and the purpose of the data, there are many different types of sorting algorithms. Most often, the most efficient sort algorithm is used. What makes a sorting algorithm more efficient? Is it how well the computer completes the sort? Is it how fast the computer completes the sort? Is it how much memory is required to perform the sort?

Today you will have the opportunity to test 3 different types of computer sorting algorithms. It is very important that you understand the difference between how humans and computers sort. Unlike a computer, a human can look at multiple pieces of data and make multiple decisions based upon the data. For instance, if you saw the numbers 1-10 typed out in incorrect order, you could easily put the numbers in the correct order. A computer can only compare 2 pieces of data at a time and perform an action based upon the comparison. The difference is that it can do it much faster than a human. Imagine that you were trying to organize the numbers 1-1000 in correct order. It would take a while. Today you are going to practice sorting like a computer. The important idea to remember is that you may only compare 2 pieces of data at a time. In this case it will be playing cards.

Overview of 3 Sorting Algorithms

A **Bubble Sort** begins with an unsorted array. To perform a Bubble Sort, the first 2 items on the left side of the array will be compared. If the item to the right is out of order, swap the items. Keep swapping with the item on the right until the item is in its correct spot. This is counted as 1 pass. Go back to the start of the array, and sort again until another item has moved to its correct position. This would be pass 2. Continue until all items are in their correct positions.

An **Insertion Sort** starts with an unsorted array. A marker (straw) will separate the unsorted items (on the right) from the sorted items (on the left). Compare the first two items. If they are not in the correct order, swap them and move the marker forward one piece. If the items are in correct order, move the marker forward. Compare the item on the left of the marker with the next item on the right. Swap them if they are not in correct order. If an item is swapped and moved to the left of the marker, compare it with the other sorted items until it is placed in its correct position. Continue to compare and swap items, moving the marker forward until there are no more cards to the right of the marker.

A **Merge Sort** begins by dividing an array in half. Begin with one half of the divided array and divide it in half. Continue to divide it in half until each item is a single item. If there is an uneven number, for instance 3 items, one item is a single, and two are a pair. The pair is then divided. Then the sort begins. Sort the divided pairs by placing the items in their correct order. Combine (merge) the pairs by comparing the first item in each array

and making a new, sorted array that consists of all the items in the first half. Follow this process with the second half of the array. Merge the 2, sorted arrays into one by comparing the first 2 items on the left and sorting them until no new items remain in the 2 arrays. The result will be a new, sorted array.

Go back to the first number and begin the next pass. Keep sorting until numbers are in their correct position. In this example, it would take 4 passes to complete the sort.

Now answer questions 2 and 3 from the Hand-Out sheet.

Insertion Sort

Your goal is to put a suit of cards in order from Ace to King.

Answer question 4 from the Hand-Out sheet.

Instructions: Cards on the left of the marker are sorted. Cards on the right are unsorted.

1. Take one set of cards out of the bag.
2. Shuffle them and lay them in a row facing down on the table.
3. Turn over the first card on the left.
4. Place the marker (straw) between the first and second cards on the left.
5. Now turn over the card to the right of the straw.
6. If the card to the right of the straw is smaller than the card on the left, swap them. If they are in order then move the straw over one card.
7. Every time the straw marker is moved forward it is a pass.
8. Keep track of how many passes it takes to complete the sort.
9. Once you move the straw forward, turn over the card to the right of the straw.
10. Compare the card on the left side of the marker with the next card on the right.
11. If the card on the right is smaller, swap the cards. Continue to compare the swapped card with the sorted cards (moving to your left). Continue swapping cards until the card is in its correct position. Notice that you are “inserting” the card on the right side of the straw into its correct position on the left side of the straw.
12. Continue until all the cards have been turned over and sorted. The sort is complete.

Example:

Unsorted Cards: 2 5 ? ? ? ?

The straw is placed between the 2 and 5. 2 is less than 5, so no swapping occurs. Move the marker over one spot and turn over the next card. It is a 1.

The order of the cards is now: 2 5 1 ? ? ?

Now compare 5 and 1. They are out of order so swap them.

The order of the cards is now: 2 1 5 ? ? ?

Now compare 2 and 1. They are out of order so swap them.

The order of the cards is now: 1 2 5 ? ? ?

Move the straw over one space and turn over the next card. It is a 6. Compare 5 and 6. They are in the correct order so you are done.

The order of the cards is now: 1 2 5 6 ? ?

Move the straw over one space and turn over the next card. It is a 3. Compare 6 and 3. They are out of order so swap them.

The order of the cards is now: 1 2 5 3 6 ?

Continue comparing 3 until it is in its correct position. (Just one more comparison!)

The order of the cards is now: 1 2 3 5 6 ?

At this point you would move the marker over one spot and turn over the last card. You would then compare that last card and swap until it ended up the right position and all the cards would be sorted.

A total of 5 passes would be needed to complete this sort.

Now answer questions 5 and 6 on the Hand-Out sheet.

Merge Sort

Your goal is to put a suit of cards in order from Ace to King.

Instructions:

1. Take one set of cards out of the bag.
2. Shuffle them and split the deck in half.
3. Give each half of the deck to someone else.
4. Now the people with the cards should split their pile in half, and give each half to a different person. (If you don't have enough people in your group, just set a pile on the table and you can come back to it.)
5. Keep halving the piles of cards and giving the halves away until you can no longer split the cards. You should have people with one card each.
6. Each group of two people should compare cards and put them down on the table in order. You should now have 6 pairs of ordered cards and one single card (there are 13 cards in a suit).
7. You will now "merge" two sets of cards:
 - (a) Look at the first card in each group of cards.
 - (b) Move the lowest card into position in a new spot on the table.
 - (c) Continue comparing the first card in each set and moving the smallest into its new position until there are no more cards in the original sets. You have now "merged" two sets of cards into a single sorted list.
8. Continue to merge sets of cards until you only have one sorted set.

Example:

Unsorted Cards: 4 8 3 6 5 1 7

When they are split in half, you now have: 4 8 3 6 5 1 7

Split in half again, you have: 4 8 3 6 5 1 7

Now they would be split again into single cards, and then we can begin merging them. First we put the pairs in order.

The cards are now: 4 8 3 6 1 5 7

We will now merge the first two pairs. Look at the first card in each pair and move the lowest to a new list. This results in: 4 8 6 **New List 3**

Now look at the first card in each pair and move the lowest to the new list. This results in: 8 6 **New List 3 4**

We continue to merge. We end up with: **New List 3 4 6 8**

We have finished “merging” one half of the cards. Repeat the process with the other half of the cards. You should end up with two sorted lists:

New List 3 4 6 8 **New List 1 5 7**

Now you just have to merge these two lists and you will be done!

Answer questions 7, 8, and 9 on the Hand-Out sheet.

Hand-Outs

Questions

1. Before you try the Bubble Sort, predict how many passes it will take to complete the sort.
2. How many passes did it take to finish the Bubble Sort?
3. Try it 2 or 3 more times and record the number of passes. Be sure to shuffle the cards before starting the next sort. Was the number of passes the same or different each time? What might affect the number of passes?
4. Predict the number of passes it will take to complete the Insertion sort.
5. Try it 2 or 3 more times and record the number of passes, shuffling cards before each sort. Was the number of passes the same or different? What might affect the number of passes?
6. Which sort do you think is quicker, Bubble Sort or Insertion Sort? Time how long it takes you to complete each sort. Were you right in your prediction?
7. Which of the 3 sorts do you think was most efficient for sorting 1 suit of cards? Why?
8. Which sort do you think would be most efficient if you wanted to sort 2 suits of cards? How about 4 suits of cards? If you have time, combine and shuffle the 4 suits and try each sort.
9. Which sort was least efficient? Which sort was most efficient? Why?



Resupply

- Pencils are sharpened
- Make sure all ziploc bags have complete suit of cards