Comparable

I DON'T GET YOUR CODE. WHAT ARE THESE LINES FOR?

I HAVE NO IDEA. BUT IT DOES NOT WORK WITHOUT THEM

THE ART OF PROGRAMMING - PART 2: KISS
Storing Multiple Choice Quizzes

The text files:
- Each text file corresponds to answers for a multiple choice quiz.
- Each line contains one answer.
- For each quiz, answers.txt represents the correct answers.

MCQuiz Class

```java
public class MCQuiz {
    private String studentName;
    private String quizName;
    private List<String> correctAnswers;
    private List<String> studentAnswers;

    public MCQuiz(String filename) throws FileNotFoundException { ... }

    public String getStudent() { ... }
    public String getName() { ... }
    public int numberCorrect() { ... }
}
```

We would like to do the two following tasks:

1. Print out the quizzes in worst-to-best order (e.g. sort the quizzes)
2. Collect all quizzes of each particular student together and display them (still from worst-to-best)
A few lectures ago, we sorted the characters of a string. Let’s sort more:

**Sorting An Integer List**

```java
public static void sortIntList(List<Integer> list) {
    for (int i = 0; i < list.size(); i++) {
        int minIndex = i;
        for (int j = i; j < list.size(); j++) {
            if (list.get(j) < list.get(minIndex)) {
                minIndex = j;
            }
        }
        int temp = list.get(minIndex);
        list.set(minIndex, list.get(i));
        list.set(i, temp);
    }
}
```

**Sorting A String List**

```java
public static void sortStringList(List<String> list) {
    for (int i = 0; i < list.size(); i++) {
        int minIndex = i;
        for (int j = i; j < list.size(); j++) {
            if (list.get(j).compareTo(list.get(minIndex)) < 0) {
                minIndex = j;
            }
        }
        String temp = list.get(minIndex);
        list.set(minIndex, list.get(i));
        list.set(i, temp);
    }
}
```
Strings have a method called `compareTo` that works like `<` does on ints. If we have two strings:

```
String hello = "hello" and String bye = "bye"
```

To do the test “hello < bye”, we do the following:

1. Write what we want: `hello < bye`
2. Subtract the right from both sides: `hello - bye < 0`
3. Replace the subtraction with `compareTo`:
   ```java
   hello.compareTo(bye) < 0
   ```

That’s it!
### Sorting A MCQuiz List

```
public static void sort(List<MCQuiz> list) {
    for (int i = 0; i < list.size(); i++) {
        int minIndex = i;
        for (int j = i; j < list.size(); j++) {
            if (list.get(j).numberCorrect() < list.get(minIndex).numberCorrect()) {
                minIndex = j;
            }
        }
        MCQuiz temp = list.get(minIndex);
        list.set(minIndex, list.get(i));
        list.set(i, temp);
    }
}
```

Strings were easier, because they knew how to compare themselves.

### Implementing A compareTo

```
public int compareTo(MCQuiz other) {
    // From above: list.get(j).numberCorrect() < list.get(minIndex).numberCorrect()
    // Replacing: this.numberCorrect() < other.numberCorrect()
    // Converting: this.numberCorrect() - other.numberCorrect() < 0
    return this.numberCorrect() - other.numberCorrect();
}
```

### Sorting An MCQuiz List

```
if (list.get(j).compareTo(list.get(minIndex)) < 0) {
    minIndex = j;
}
```
How do sort and TreeSet work?

How do sort and TreeSet **KNOW** the ordering?

If you were implementing sort for a type T, what would you need to be able to do with T a and T b?

**We would need to be able to COMPARE a and b**

That’s just an interface! Java calls it “Comparable”.

**Comparable**

The Comparable interface allows us to tell Java how to sort a type of object:

```java
public interface Comparable<E> {
    public int compareTo(E other);
}
```

This says, “to be Comparable, classes must define compareTo”.
Client Code to Print The Quizzes

```java
List<MCQuiz> quizzes = createQuizzes(2);
// First, let’s get a sorted list of the quizzes
Collections.sort(quizzes);
for (MCQuiz quiz : quizzes) {
    System.out.println(quiz);
}
```

This doesn’t work, because Java doesn’t know how to sort MCQuizzes.

Comparable

The Comparable interface allows us to tell Java how to sort a type of object:

```java
public interface Comparable<E> {
    public int compareTo(E other);
}
```

This says, “to be Comparable, classes must define compareTo”. 
public class MCQuiz implements Comparable<MCQuiz> {
    ...
    public int compareTo(MCQuiz other) {
        return this.numberCorrect() - other.numberCorrect();
    }
}

This doesn’t work, because if we have a quiz where someone got 1/10 and another where someone else got 1/5, we treat them as the same.

public class MCQuiz implements Comparable<MCQuiz> {
    ...
    public int compareTo(MCQuiz other) {
        return (double) this.numberCorrect() / this.correctAnswers.size() -
               (double) other.numberCorrect() / other.correctAnswers.size();
    }
}

This won’t even compile! We need to return an int.
int Fields

If we have a field `int x` in our class, and we want to compare with it, our code should look like:

```java
public class Sample implements Comparable<Sample> {
    public int compareTo(Sample other) {
        return Integer.compare(this.x, other.x);
    }
}
```

Object Fields

If we have a field `Thing x` in our class, and we want to compare with it, our code should look like:

```java
public class Sample implements Comparable<Sample> {
    public int compareTo(Sample other) {
        return this.x.compareTo(other.x);
    }
}
```

In other words, just use the existing `compareTo` on the field in the class!
MCQuiz: Defining compareTo

Attempt #3

```java
public class MCQuiz implements Comparable<MCQuiz> {
    ...
    public int compareTo(MCQuiz other) {
        double thisPer = this.numberCorrect() / this.correctAnswers.size();
        double otherPer = other.numberCorrect() / other.correctAnswers.size();
        return Double.compare(thisPer, otherPer);
    }
}
```

This **still** doesn't work, because it doesn't take the **names** of the students into account.

In particular, if two students both get 1/10 on a quiz, our compareTo method says “it doesn’t matter which one goes first”.

Attempt #4

```java
public class MCQuiz implements Comparable<MCQuiz> {
    ...
    public int compareTo(MCQuiz other) {
        double thisPer = this.numberCorrect() / this.correctAnswers.size();
        double otherPer = other.numberCorrect() / other.correctAnswers.size();
        int result = Double.compare(thisPer, otherPer);
        if (result == 0) { result = this.studentName.compareTo(other.studentName); }
        return result;
    }
}
```

This **still** doesn't work, but it’s not as clear why. Let's try the second task.
Grouping the Quizzes by Student

What data structure should we use to group the quizzes? **A Map!**

Map Question: “Which quizzes were taken by this student?”
Keys: **Strings** (the student names)
Values: **Set<MCQuiz>** (all the quizzes that student took).

```java
List<MCQuiz> quizzes = createQuizzes(2);
Map<String, Set<MCQuiz>> quizzesByStudent = new TreeMap<>();

// We want to loop over all the quizzes, adding them one by one
for (MCQuiz quiz : quizzes) {
    String name = quiz.getStudent();
    if (!quizzesByStudent.containsKey(name)) {
        quizzesByStudent.put(name, new TreeSet<MCQuiz>());
    }
    quizzesByStudent.get(name).add(quiz);
}

// Now, we want to print out the quizzes student by student:
for (String student : quizzesByStudent.keySet()) {
    System.out.println(student + ": " + quizzesByStudent.get(student));
}
```
Grouping the Quizzes by Student

The output looks like this:

>> BarbaraHarris: [BarbaraHarris (quiz1): 3/11, BarbaraHarris (quiz0): 4/11]
>> JessicaHernan: [JessicaHernan (quiz1): 1/11, JessicaHernan (quiz0): 2/11]
>> TeresaHall: [TeresaHall (quiz0): 4/11]

Why does Teresa only have one quiz? She scored the same on both of her quizzes and compareTo said they were the same!

Final Attempt

```java
public class MCQuiz implements Comparable<MCQuiz> {
    ...
    public int compareTo(MCQuiz other) {
        double thisPer = this.numberCorrect()/this.correctAnswers.size();
        double otherPer = other.numberCorrect()/other.correctAnswers.size();
        int result = Double.compare(thisPer, otherPer);

        if (result == 0) {
            result = this.studentName.compareTo(other.studentName);
        }
        if (result == 0) {
            result = this.quizName.compareTo(other.quizName);
        }
        return result;
    }
}
```

Lesson: When you write compareTo, make sure that

\[ a\text{.compareTo}(b) == 0 \text{ exactly when } a\text{.equals}(b) \]
Some Comparable Tips

- Understand multi-level structures
- Use the most general interface as possible
- When implementing `compareTo`, make sure to use all the fields that make it different (to put another way: `a.compareTo(b) == 0` exactly when `a.equals(b)`)
- Remember that inside classes, you can look at the fields of other instances of that class