Activity 2-5a Refactoring: The `NumberPrinter` Class

This activity continues the refactoring of primeGenerator that you began in Activity 2-4.

Step 4: Refactor the `print` method

1. The first thing to clean up are the parameters for the print method: int numPrimes and int[] primes.

   a. Although the second parameters is called primes, in theory it could be any array of numbers. Perform a **Rename** refactoring to change the name of primes to numbers.

   b. The parameter numPrimes indicates how many numbers to print. We can just use the length of the numbers array instead, which makes the numPrimes parameter unnecessary. Fix this in a stepwise fashion as follows:

      - Find the first use of the numPrimes parameter.
      - Use **Extract Variable** refactoring to create a local variable called numberOfNumbers. When asked, be sure to replace all 3 occurences. Also, renaming the variable will be the last thing you do.
      - Change the numberOfNumbers = ... assignment to instead be

        ```
        numberOfNumbers = numbers.length - 1
        ```

        (Note: the numbers in the array actually start at index 1.)
      - Run the tests to make sure they still work.

   c. The numPrimes parameter should now be grayed out as it is no longer being used. Use **Safe Delete** to remove it.

      - Select the parameter.
      - Use <alt>–ENTER to show the available intentions and select **Safe Delete**.
      - Run tests again.
      - You should verify that the first parameter of 1000 in the call to print from PrimePrinter.java has also been removed.

   d. At this point you should notice that the top few lines of the while loop have changed: The old pageOffset <= numPrimes check has now been moved to a new if statement, which includes a break. We would like to move it back, but in order to do that we will need to increase the visibility of the numberOfNumbers variable to be outside of the loop.

      - Select the numberOfNumbers definition line and move it up a line so that it is outside of the while loop.
      - You should see the while keyword change color, suggesting there is an intention available. Hit <alt>–ENTER on the keyword, and choose "move condition to loop". This should place the conditional back in its proper place.

2. The next thing to do is simplify the while loop by extracting various methods.

a. The first five lines of the while loop are System.out calls. Together these lines print the header for a page. Select these lines and extract them into a method called printHeader.

b. Next, inside the while loop is the double for loop that is responsible for actually printing the numbers on the page. Extract a method called printNumbersOnPage from the double for loop.

c. The last three lines of the while loop update the pageNumber and pageOffset counters as we advance through each page. These three lines also need to be turned into a method, but you notice that, pageNumber is being used by the printHeader method, and pageOffset is being used by the printNumbersOnPage method. Also, the variable numberOfNumbers is being used by both those methods. Before turning the last three lines into a method, pageNumber, pageOffset, and numberOfNumbers need to be elevated from local variables into class fields / instance variables, so that they are visible throughout the file.

   - Select any one of the pageNumber references and refactor to **Extract Field**. Keep the same name for the name of the field.
   - Repeat the process to extract pageOffset and numberOfNumbers into fields as well.

d. Now extract a method called moveToNextPage from the last three lines of the while loop.

3. Clean up the parameters of the newly created methods.

   a. Because pageNumber and numberOfNumbers are now fields, they no longer need to be passed into the printHeader method.

      - Go down to where the printHeader method is being defined.
      - Select pageNumber in the parameter list.
      - Use refactoring to **Inline** the parameter.
      - Repeat this process to inline the numberOfNumbers parameter.
      - Remove the superfluous this that was added to the pageNumber and numberOfNumbers references in printHeader.
      - Run tests.

   b. Repeat the steps above to inline the pageOffset and numberOfNumbers parameters used by the printNumbersOnPage method. If a line is created initializing pageOffset as a local variable, delete this line.

   c. numbers is now the only parameter that remains for printNumbersOfPage, and it makes sense to also extract numbers into a field.

      - Go back to the print method.
      - Select numbers in the line initializing numberOfNumbers, and extract it as a field. Be sure to check the box to replace all occurences.
      - Now if you run your tests, they should fail, because IntelliJ did not actually add a statement to initialize this.numbers to equal the parameter numbers. Add the line this.numbers = numbers to the top of the print method.
      - Run tests to verify they are again passing.

- Back in the printNumbersOnPage method, use **Safe Delete** to delete numbers from the parameter list, and remove the superfluous self. in the next-to-last line of the method.

4. The first four lines of the print method are now all about initializing fields. Extract these lines into a method called initialize.

5. The boolean expression in the while loop is determining if there are still more numbers to print. Select this expresssion an extract it into a metho called needToPrintMore. Keep the original signature when asked, and *do not* replace other occurrences when asked.

   Your print method should now be extremely readable and straightforward.

6. The last thing to do is to clean up the printNumbersOnPage method.

   a. Down to the printNumbersOnPage method, select the three lines of the conditional inside the nested for loop and extract it as a method called printNumberAt.

   b. Go to the newly created printNumbersAt method. Although the method takes two parameters, in both places where the parameters are used in the method, they are used in the same expression: rowOffset + col * rowsPerPage.

      Instead of passing in two separate parameters, refactor and extract a parameter from the expression rowOffset + col * rowsPerPage. Check the box to replace both occurrences. The refactoring should clean up the original two parameters automatically. Call the new parameter index.

   c. Go back to the printNumbersOnPage method. rowOffset is being used as the loop variable for the outer loop. Both the initial value for rowOffset and the stopping condition are based on the value of pageOffset, which just makes the loop harder to understand. Clean this up as follows:

      - Use refactoring to rename rowOffset to row.
      - In the call to printNumberAt, change row to row + pageOffset.
      - Change the outer loop so that row begins at 0 and ends at rowsPerPage − 1.
      - Run the tests to make sure they still pass.

   d. Lastly, fix the stopping condition for each for loop to be a "less-than some value" comparison rather than a "less-than-or-equal-to some value minus one" comparison. Run your tests again.

Step 5: Reducing the number of fields

The NumberPrinter class has quite a few fields. Some of these, like pageOffset, are not used in too many places and could be replaced by a simple calculation, e.g., calculating pageOffset from pageNumber.

1. Encapsulate pageOffset so that it is only accessible through an accessor method. This "encapsulate fields" refactoring will replace all direct accesses to the pageOffset field to calls to a getter instead.

a. Select pageOffset and refactor to **Encapsulate Fields**.
b. Uncheck *Set access*. (The goal is to eliminate the need for this field, so it makes no sense to be creating a setter.)
c. Click "Refactor", to replace all accesses to this field with a call the getter getPageOffset().
d. Run tests to make sure nothing was broken.

2. Change the getPageOffset() method so that it computes the page offset from pageNumber and returns the result.

   a. The computation should be:
      ```
      (pageNumber − 1) ∗ rowsPerPage ∗ colsPerPage + 1
      ```
   b. Run our tests to make sure this change did not break anything.
   c. Now that the pageOffset field is no longer being used in a calculation, you can remove any occurrences where pageOffset was being assigned a value.
      - At the top of the class where pageOffset is grayed out, select the field, refactor and use **Safe delete** to remove the field.
      - Safe delete may report about the getter you just created. *You should NOT delete this getter.*
      - When told about usages that are not safe to delete, view the usage.
      - The bottom panel should show that pageOffset is being used in the moveToNextPage method. Double clicking on the usage in that panel will take you to that spot in the code.
      - Manually delete the line assigning a value to pageOffset.
      - Back in the bottom pane, click "Rerun Safe Delete". This time, no pageOffset usages should be found and the field should be deleted.
   d. Run the tests.

3. The numberOfNumbers field can also be removed with a bit of refactoring. It is not used much, and it can be computed easily from the numbers array.

   a. Use refactoring on numberOfNumbers to encapsulate the field. Again, you only need to create a getter for this field, not a setter.
   b. Replace the body of the new getter to instead return the length of the numbers array minus one.
   c. Run the tests to make sure nothing is broken.
   d. Remove the numberOfNumbers field from the class using **Safe Delete**.
   e. Run tests.

Step 6: Parameterizing the title

Printing the numbers includes printing the header information, title and page number, for each page. Ideally, the title should be a parameter that the method caller can provide – there is no way of knowing what *kinds* of numbers the caller will ask of the method. The logic for calculating the page number can remain unchanged.

1. Edit the printHeader method so that contains two calls: System.out.print to output the title and System.out.println to output the page number.

   a. Use the "+" operator to concatenate the different string arguments together.

   b. Eliminate the Integer.toString calls but keep their arguments; the plus operator can deal with adding strings and integers.

      The new version of printHeaer should look like the following:

      ```
      private void printHeader() {
        System.out.print("The␣First␣" + getNumberOfNumbers() + "␣Prime␣Numbers␣");
        System.out.println("——␣Page␣" + pageNumber + "\n");
      }
      ```

      Run your tests to make sure nothing got broken in the process.

2. Select everything that is being passed to the first Sytem.out... call. Use refactoring to extract this into a parameter with the name title.

3. Go up to the print method. Repeat the process of extracting

   ```
   "The␣First␣" + getNumberOfNumbers() + "␣Prime␣Numbers␣"
   ```

   into a parameter called title.

4. Run your tests, and you will discover that they are failing, which means something is now broken. Go to the PrimePrinter method in PrimePrinter.java and change the numberPrinter.getNumberOfNumbers call into a reference to the numPrimes field. This should fix the broken test.

   NOTE: Make sure you understand why this last move we made broke the tests. What was wrong with trying to access numberPrinter.getNumberOfNumbers?

5. Go back to NumberPrinter.java to the printHeader method.

   a. Add title to the second System.out... call and delete the first System.out... call, which is no longer needed.

   b. Click anywhere in the argument to the System.out... call and check available intentions. Choose **Replace "+" with String.format**. You should see the line change to a call to printf. If you are not familiar with the syntax of printf and String.format, look them up.

Step 7: Clarify the `while` loop in the `print` method

Back in the print method, consider the current structure of the while loop. This loop should be printing the next page every time it iterates, but its current structure does not allow for that.

Part of the problem is that the page number is represented by a field, and it is mysterious how it is getting updated:

– It gets an initial value in the 'initialize' method, but nothing in the name of that method sugges
– Then, the page number is being upated in the 'moveToNextPage' method at the end of the 'while' loop

Ideally, the loop should have the following structure:

```
while there is a next page:
    print the next page
```

or even better:

```
for page in pages:
    print page
```

In Java syntax, this would look like:

```java
for (int page : getPages())
    printPage(page)
```

To achieve this, you need an iterator. But before adding an iterator, you need to refactor the methods that are being called in the while loop to take the page number as an argument. All three method calls use the pageNumber field:

- printHeader uses it to print the page number on the header.
- printNumbersOnPage uses it in its getOffset calculation.
- moveToNextPage actually increments it, which complicates matters considerably.

The steps to accomplish this refactoring are below:

1. Go to the printHeader method and find the use of pageNumber in this method. Use refactoring to extract pageNumber into a parameter, and check that all tests still pass.
2. Go to the moveToNextPage method. Use refactoring to inline and remove the method. This method will not be doing much once the page increment has been moved around; you will find a better place for the System.out... call later.
3. Repeat the inline and remove refactor on the initialize method.
4. Go to the getPageOffset method. Find the use of pageNumber and extract it as a parameter.
5. Go to the printNumbersOnPage method and repeat the process of extracting pageNumber as a parameter.
6. Finally, go to the needToPrintMore method. This method uses pageNumber in its call to getPageOffset; again extract pageNumber as a parameter. Run your tests.

7. All changes to the pageNumber field should now be isolated to the print method. At the beginning of method, pageNumber is set to 1, and pageNumber is being incremented at a natural spot at the end of the while loop. You can confirm that the pageNumber field is not used elsewhere by moving your cursor over the field declaration and using the *Navigate -> Declaration* menu item. This action should show you all the places pageNumber is being used, and they should all be in the few lines of code of the print method.
8. Notice also that the pageNumber field is grayed out in its definition. This often suggests that you can restrict its visibility, by making it private or turning it into a local variable, and we will do the latter. With the cursor on the pageNumber field declaration, choose the **Convert to local** intention.
9. Run your tests again to make sure everything is still working.

Step 8: Extracting a Page class

Thinking through the problem more, it almost feels like there needs to be a separate class to capture the idea of individual *pages*. Such a class could incorporate the logic about computing indices and knowing when it is done, for example. Let's think through what this new Page class would need to know:

- It needs to know its number, currently stored in pageNumber.
- It needs to know the row/column dimensions.
- It needs to know the actual numbers array to be able to index into it.

This class will kind of end up knowing almost all the same stuff as the pretty-printer (except for the title for example). But it does not concern itself with headers and footers for example, or where to output the values. Later we might consider other ways to paginate the page (e.g. numbers going row-first). The steps below give this refactoring a try.

1. Turn the pageNumber local variable back into a field (extract field). This prepares you to do an **Extract Delegate** refactoring, which works best with fields.
2. With the cursor anywhere in the NumberPrinter method, refactor to **Extract Delegate**. This refactoring will allow you to pull fields and methods of one class to create another class.
    a. Name the new class Page.
    b. Include all members in the Page class except for print, printHeader and printNumbersOnPage. Make sure to select the "generate accessors" box.
3. If you run your tests now, they should fail, complaining that rowsPerPage and columnsPerPage are marked as final. This is actually correct, since these fields should really only be set once in the constructor. However, that is not how these fields are currently being set.

a. Go to NumberPrinter.java. At the top of the class you will find that the page field is being initialized as part of its declaration. Click anywhere in that line then view available intentions. Select **Move initializer to constructor** to move the initialization of page into the constructor.

b. Back in Page.java, select the rowsPerPage field and view available intentions.

- Select the **Add constructor parameters** intention.
- In the window that opens, select both rowsPerPage and colsPerPage to add as parameters.
- Click "Refactor" to change the signature of the Page constructor.

c. The methods setRowsPerPage, setColsPerPage, and getNumbers are now no longer being used; remove them using **Safe Delete**.

d. Go to the NumberPrinter constructor, delete the two this.page.set... lines.

e. Run tests to verify that everything is once again working.

4. Finish up this part of the refactoring process with some cleaning up.

a. Use **Safe delete** to remove the methods in the NumberPrinter class that are no longer being used.

b. Inside the print method, there is a page.setPageNumber(1) call that really should be part of the initialization of the Page class. Delete that call in print, then go to the Page class and instead initialize the pageNumber to 1.

c. pageNumber is now a field for the Page class, which means the getPageOffset method no longer needs the pageNumber parameter.

- Refactor and use **Change signature** to eliminate this parameter.
- Ignore the problem that is detected and continue.
- Run tests!

d. Use the **Safe delete** intention to remove pageNumber as a parameter for the needToPrintMore method, then use refactoring to rename the method to hasNext.

e. Go back to NumberPrinter.java. Note the last line of the while loop in print is using the setPageNumber method to increment the page number by 1. This really should be a method of the Page class.

- Select the whole expression (page.setPageNumber(page.getPageNumber() + 1)) and use "Extract method" refactoring to turn it into a new method called nextPage.
- Accept the suggested signature change and the change to the line of code.
- Go to the nextPage method that was just created, and use refactoring to move the method into the Page class.
- Go find nextPage in the Page class. In the body of this function, select setPageNumber. Use refactoring to inline **this only and keep the method**.

f. Use the **Safe delete** intention to remove the setPageNumber method, which is no longer being used.

g. To further clean up the Page class:

- Move the four field declarations so that they are together at the top of the class. (You can use the *Code -> Move Statement Up/Down* shortcuts.)
- Move the constructor to be right below the field declarations.
- Move the various get... methods so that they are together below the constructor.

h. Go to the printNumberAt method. This method is not quite doing what it should be doing for this class. We want this class to be about computing, for example to compute the index, leaving the actual printing to the NumberPrinter class. To fix this you need to start at the print method in the NumberPrinter class.

- The print method calls printNumbersOfPage. Go to the printNumbersOnPage method and look at the index computation in the argument to the printNumberAt call inside the inner for loop. Select that whole argument and extract a method called getIndexFor.
- Move the getIndexFor method to the Page class; inline the call to getRowsPerPage after you have moved the function.
- Back in the printNumbersOnPage method, inline the call to printNumberAt (which will remove the method as this is its only occurence).
- At this point the system created a local variable (i or possibly index). Inline this variable to eliminate it.
- The boolean expression inside the if should be its own method; extract it to a method called hasEntry and move that new method to the Page class.
- The second argument to the String.out.printf call should also be its own method, called getEntryAt. This is a bit tricky: Select it and start the "Extract Method" refactoring, and you will see that the "Fold parameters" box is checked. Uncheck it, then refactor it and move it to the Page class.
- As a final cleanup, **Safe delete** the pageNumber parameter in the printNumbersOnPage method.

5. Go back to the print method. Remember that the goal was to simplify the loop in this method. Start by extracting a new method out of the function calls that make up the body of the while loop. Call the new method printPage. The while loop should look much simpler!

6. There are still some things off about the order in which things are happening in the new printPage method. We should be going to the "next page" first. Move the page.nextPage() line up a bit so that it is the first line in the method body. This change, unfortunately, causes the tests to fail. To fix this requires pageNumber to be adjusted in a number of ways:

   - pageNumber should start at 0 instead of 1; fix this in the field declaration at the top of the Page class.
   - hasNext should use a new method called getNextPageOffset instead of getPageOffset; this new method is like getPageOffset but uses pageNumber instead of pageNumber − 1.

   After you have made those changes and created the new method, your tests should again pass.

7. One final cleanup before calling it a day: The second parameter to printHeader can be inlined. Do that. And the System.out.println("\f"); line should really be a method called printFooter, so extract that, then rearrange the methods so that they follow the stepdown rule.

You should at this point commit your work.

This activity continues in refactoring activity 3[1].

[1] activity2-5bRefactoringPrimesGeneratorPart3.html