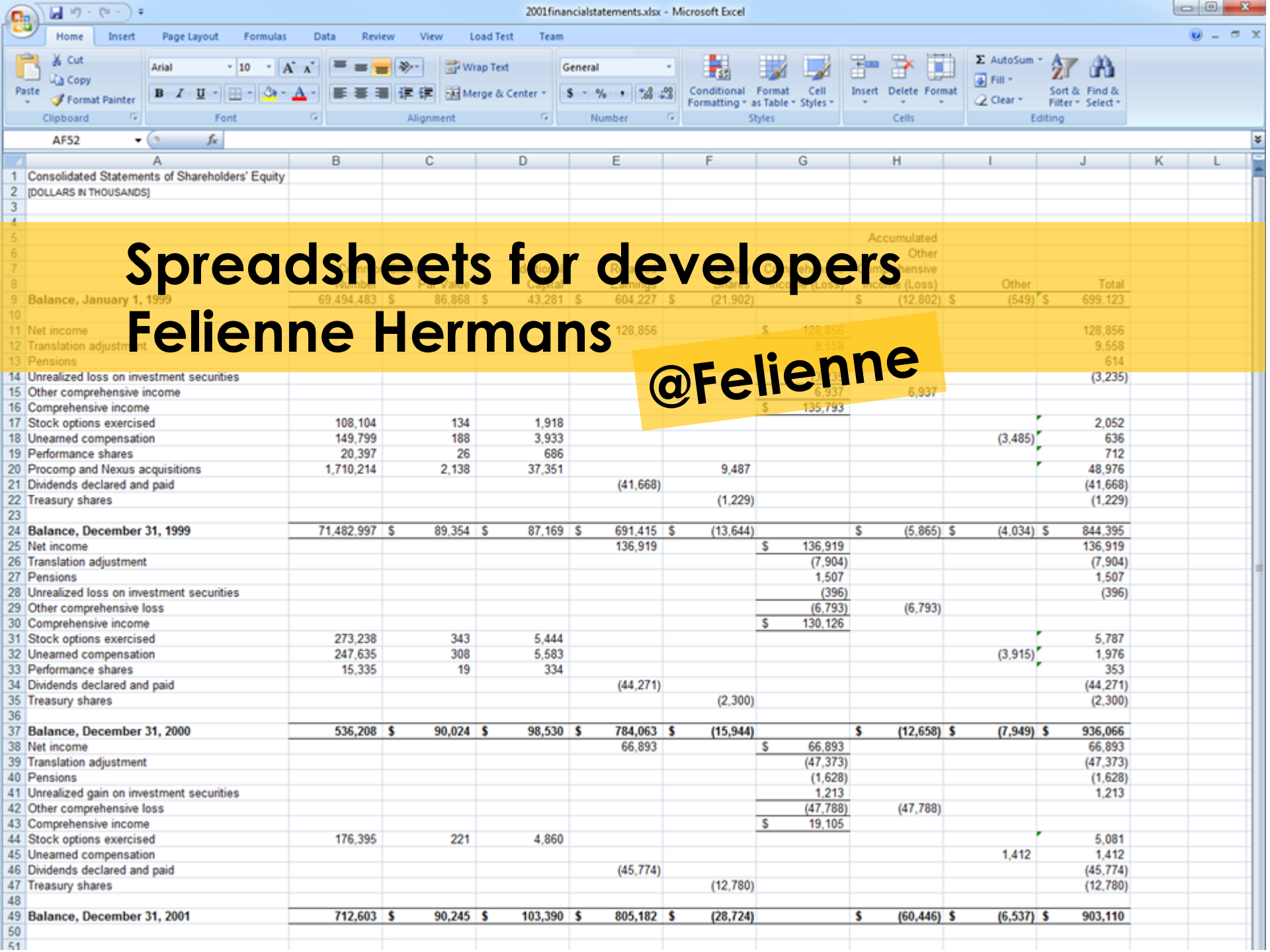
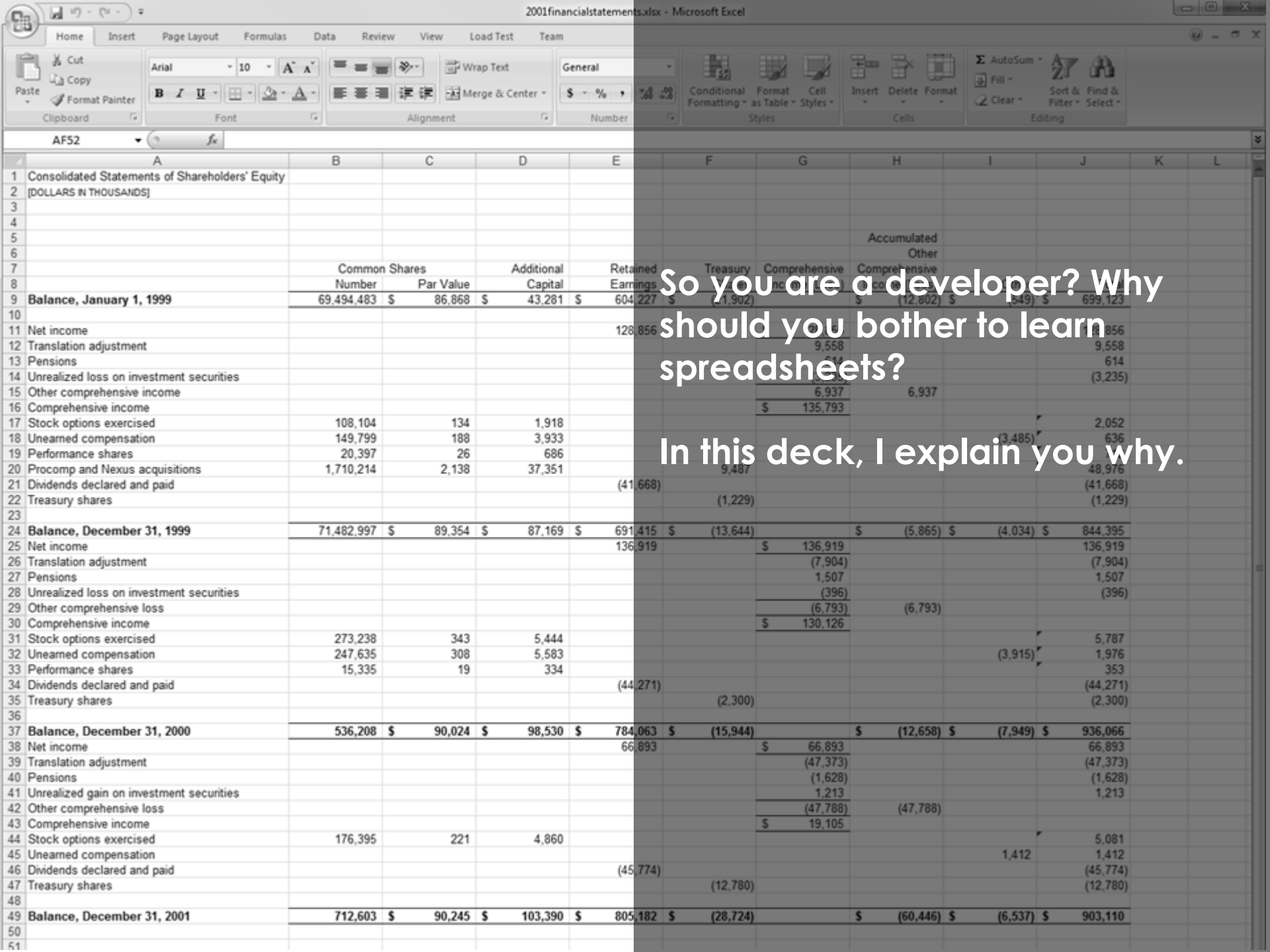
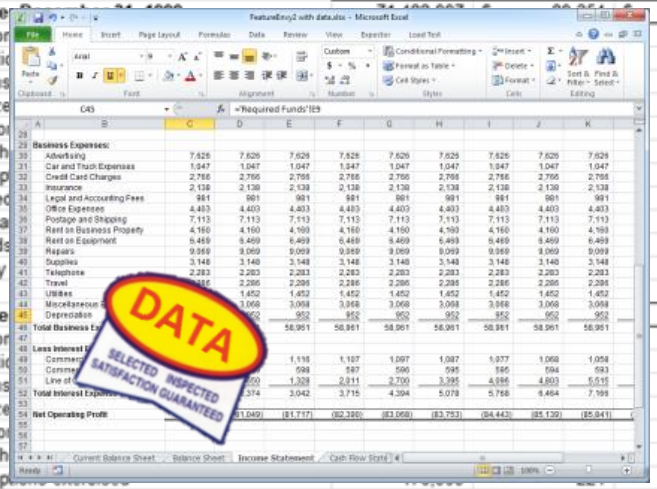


	A	B	C	D	E	F	G	H	I	J	K	L
1	Consolidated Statements of Shareholders' Equity											
2	[DOLLARS IN THOUSANDS]											
3												
4												
5									Accumulated			
6									Other			
7									Comprehensive			
8		Number	Par Value	Capital	Earnings	Shares	Income (Loss)	Income (Loss)	Other	Total		
9	**Balance, January 1, 1999**	69,494,483	$ 86,868	$ 43,281	$ 604,227	$ (21,902)		$ (12,802)	$ (549)	$ 699,123		
10												
11	Net income				128,856		$ 128,856			128,856		
12	Translation adjustment						9,558			9,558		
13	Pensions						614			614		
14	Unrealized loss on investment securities						(3,235)			(3,235)		
15	Other comprehensive income						6,937	6,937				
16	Comprehensive income						$ 135,793					
17	Stock options exercised	108,104	134	1,918						2,052		
18	Unearned compensation	149,799	188	3,933					(3,485)	636		
19	Performance shares	20,397	26	686						712		
20	Procomp and Nexus acquisitions	1,710,214	2,138	37,351		9,487				48,976		
21	Dividends declared and paid				(41,668)					(41,668)		
22	Treasury shares					(1,229)				(1,229)		
23												
24	**Balance, December 31, 1999**	71,482,997	$ 89,354	$ 87,169	$ 691,415	$ (13,644)		$ (5,865)	$ (4,034)	$ 844,395		
25	Net income				136,919		$ 136,919			136,919		
26	Translation adjustment						(7,904)			(7,904)		
27	Pensions						1,507			1,507		
28	Unrealized loss on investment securities						(396)			(396)		
29	Other comprehensive loss						(6,793)	(6,793)				
30	Comprehensive income						$ 130,126					
31	Stock options exercised	273,238	343	5,444						5,787		
32	Unearned compensation	247,635	308	5,583					(3,915)	1,976		
33	Performance shares	15,335	19	334						353		
34	Dividends declared and paid				(44,271)					(44,271)		
35	Treasury shares					(2,300)				(2,300)		
36												
37	**Balance, December 31, 2000**	536,208	$ 90,024	$ 98,530	$ 784,063	$ (15,944)		$ (12,658)	$ (7,949)	$ 936,066		
38	Net income				66,893		$ 66,893			66,893		
39	Translation adjustment						(47,373)			(47,373)		
40	Pensions						(1,628)			(1,628)		
41	Unrealized gain on investment securities						1,213			1,213		
42	Other comprehensive loss						(47,788)	(47,788)				
43	Comprehensive income						$ 19,105					
44	Stock options exercised	176,395	221	4,860						5,081		
45	Unearned compensation								1,412	1,412		
46	Dividends declared and paid				(45,774)					(45,774)		
47	Treasury shares					(12,780)				(12,780)		
48												
49	**Balance, December 31, 2001**	712,603	$ 90,245	$ 103,390	$ 805,182	$ (28,724)		$ (60,446)	$ (6,537)	$ 903,110		
50												
51												



So you are a developer? Why should you bother to learn spreadsheets?

In this deck, I explain you why.



So you are a developer? Why should you bother to learn spreadsheets?

In this deck, I explain you why.

People often think about spreadsheets as data, but that is a gross misslabeling.

Spreadsheets are code

Spreadsheets are code

I have made it my life's work to spread the happy word

"Spreadsheets are code!"

Spreadsheets are code

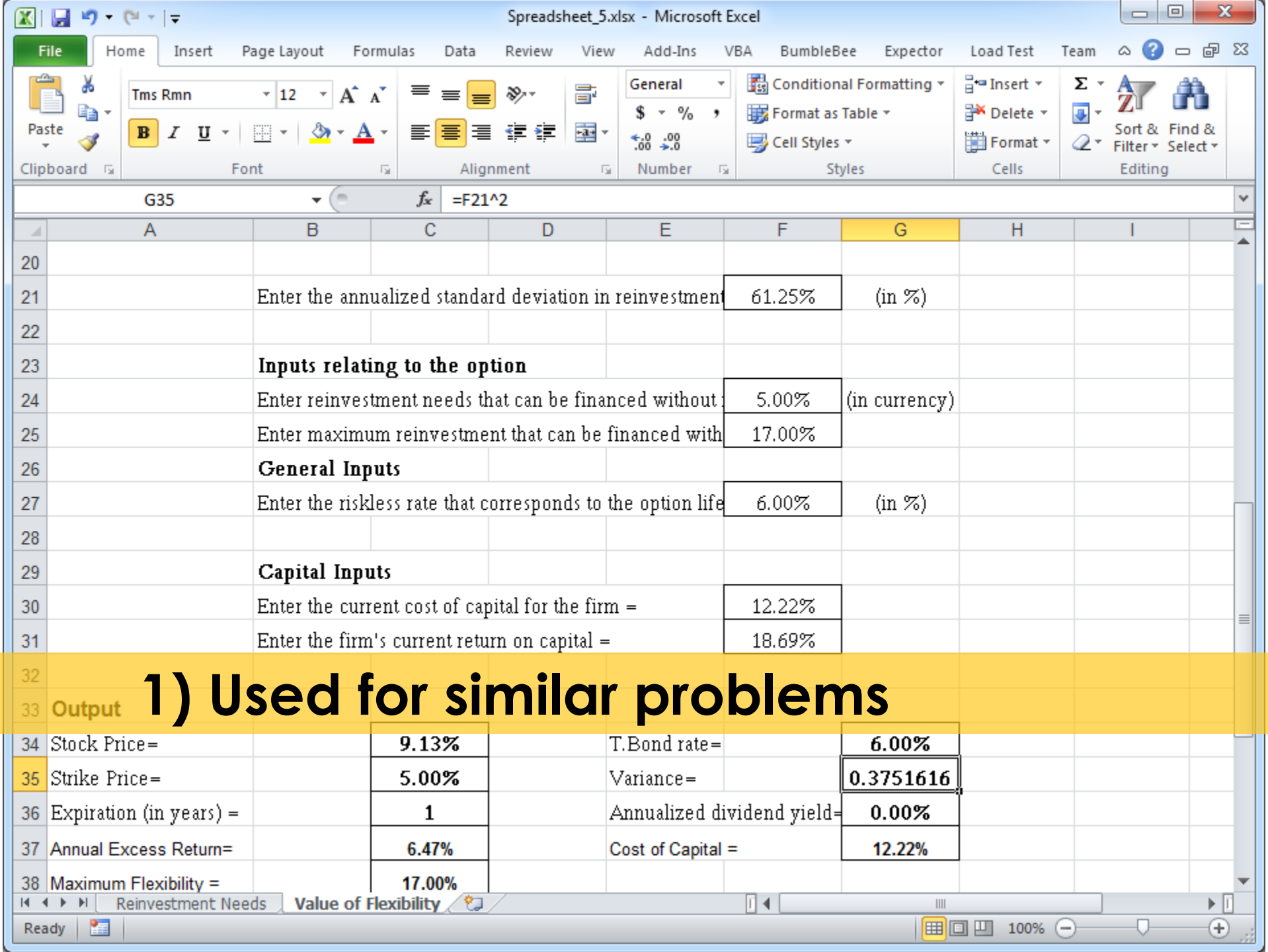
I have made it my life's work to spread the happy word

"Spreadsheets are code!"

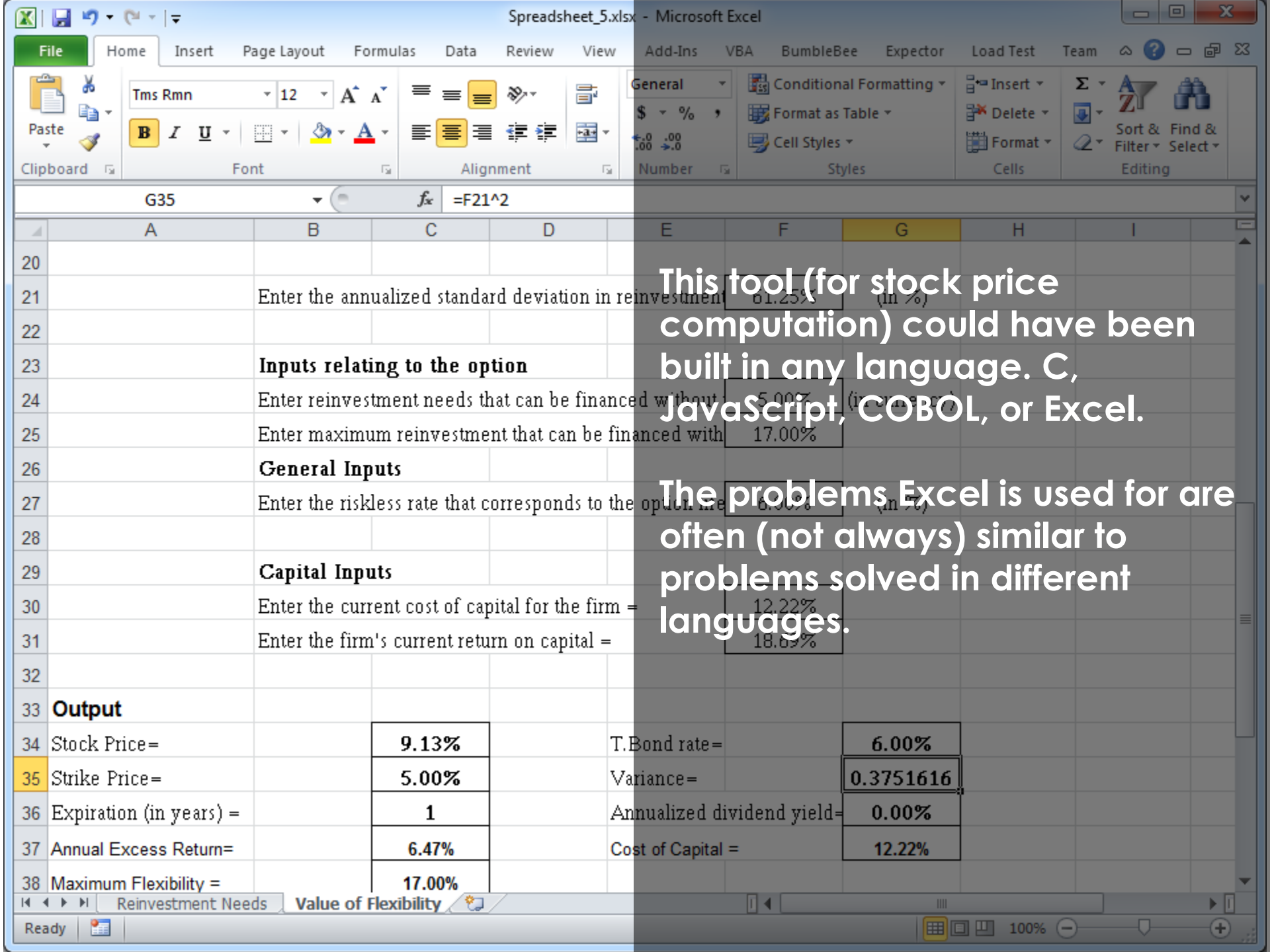
If you don't immediately believe me, I have three reasons*

* If you do believe me, skip the next 10 slides ;)

Spreadsheets are code

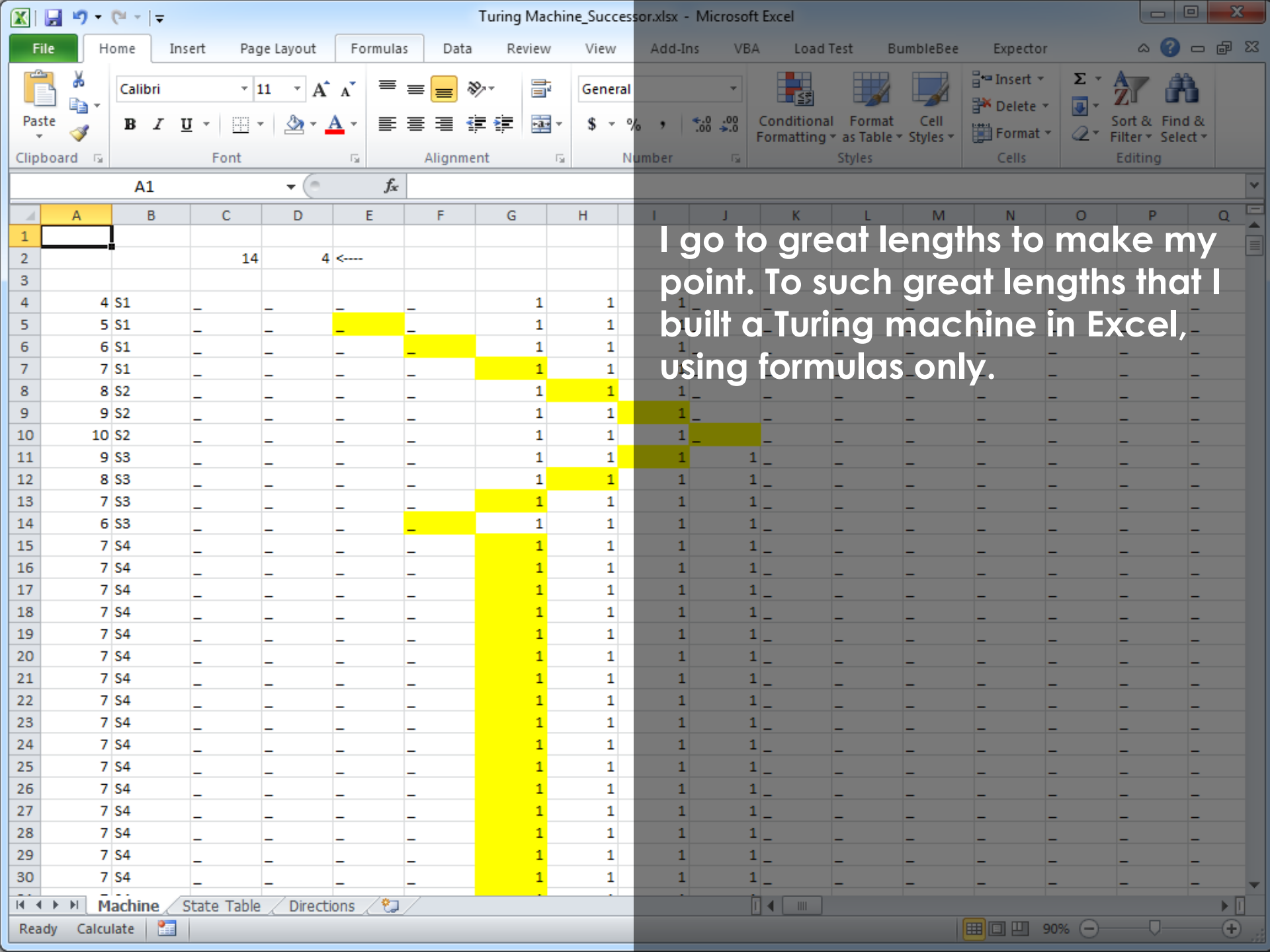


1) Used for similar problems



This tool (for stock price computation) could have been built in any language. C, JavaScript, COBOL, or Excel.

The problems Excel is used for are often (not always) similar to problems solved in different languages.


Turing Machine_Successor.xlsx - Microsoft Excel
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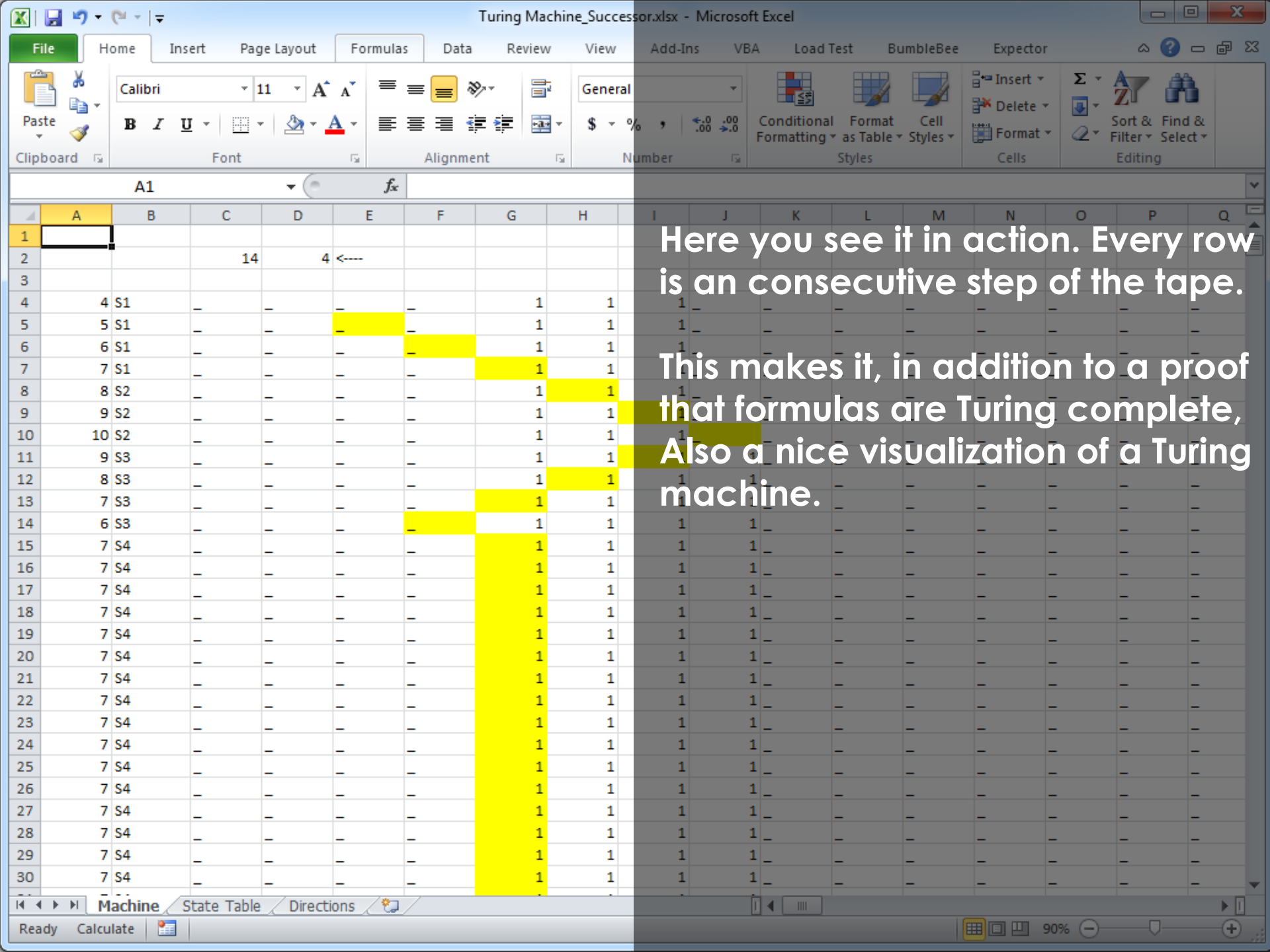
4 <----
I go to great lengths to make my point. To such great lengths that I built a Turing machine in Excel, using formulas only.
Machine
State Table
Directions
Ready
Calculate
90%


Turing Machine_Successor.xlsx - Microsoft Excel
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Editing
A1
14
4
<----
Machine
State Table
Directions
Ready
Calculate
90%
Here you see it in action. Every row is an consecutive step of the tape.
This makes it, in addition to a proof that formulas are Turing complete, Also a nice visualization of a Turing machine.

Implementing a Turing m

boingboing.net/2013/09/20/implementing-a-turing-machine.html

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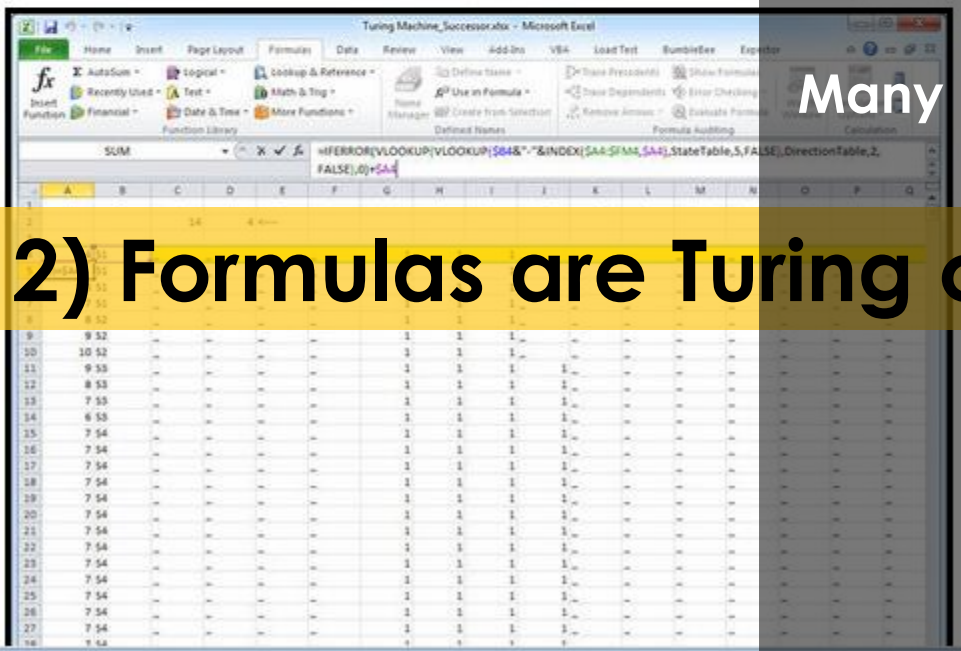
boing boing

Implementing a Turing machine in Excel

Cory Doctorow at 2:20 pm Fri, Sep 20, 2013

74 Like 142 Tweet Submit 24 g+1



Here you see it in action. Every row is an consecutive step of the tape.

This makes it, in addition to a proof that formulas are Turing complete, also a nice visualization of a Turing machine.

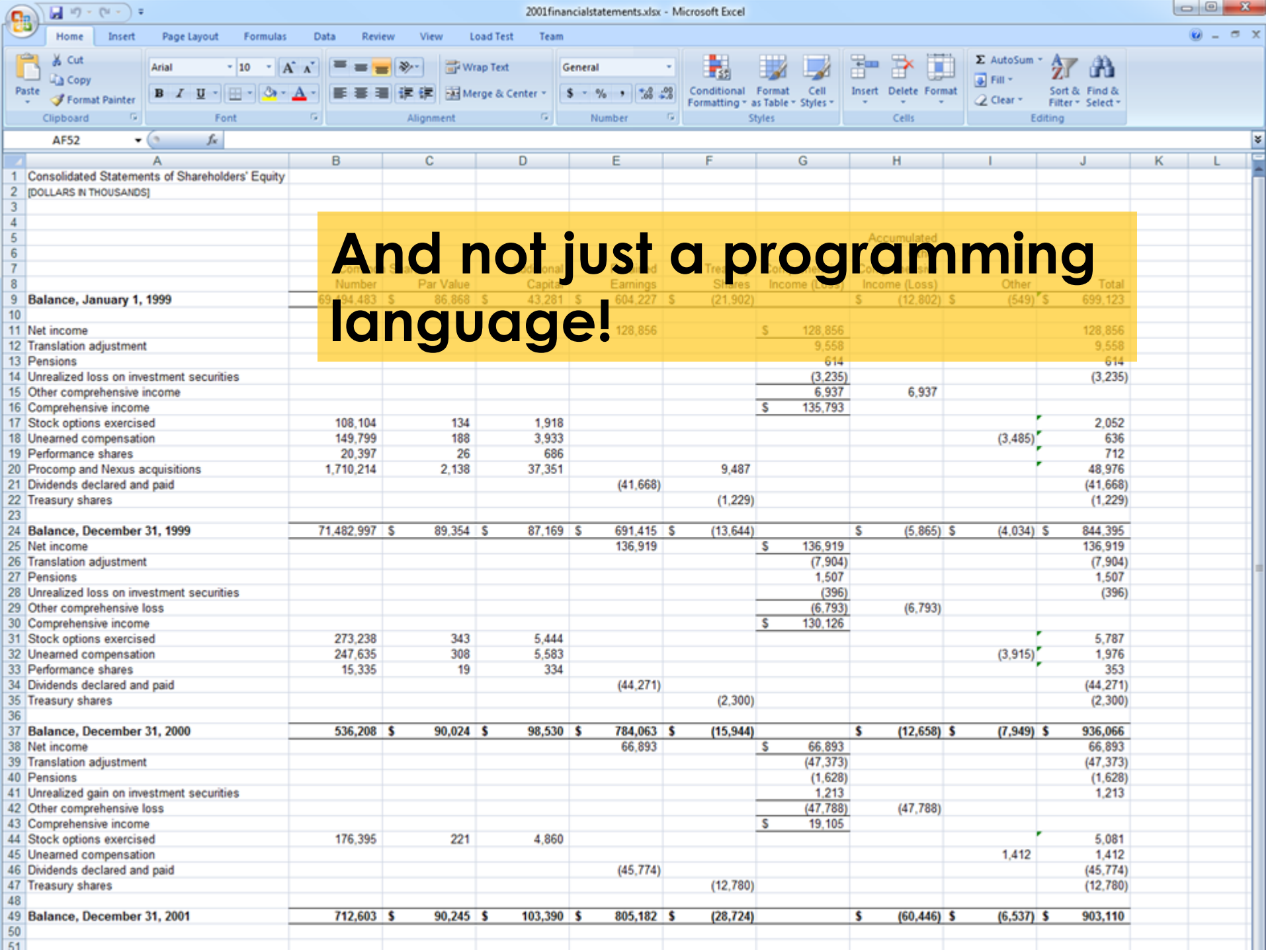
Many people liked it :)

2) Formulas are Turing complete

3) They suffer from the same problems

Spreadsheets are code

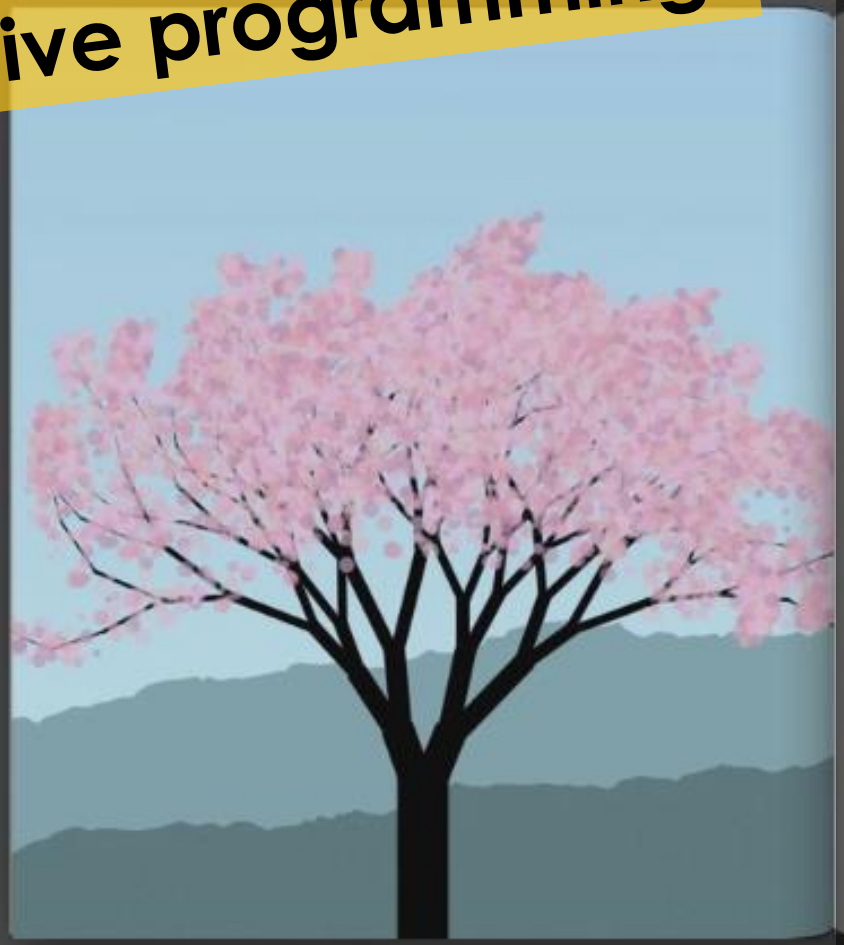
In summary: both the activities, complexity and problems are the same



And not just a programming language!


I argue that Excel is the next language to learn
Resistance is futile!

live programming



```
    canvasHeight = parseInt(canvas.getAttribute("height"));

    drawSky();
    drawMountains();
    drawTree();
}

//
//

function drawSky () {
    ctx.save();
    gradient.addColorStop(0, "#b4e0fe");
    ctx.fillStyle = gradient;
    ctx.restore();
}

//
//

function drawMountains () {
    resetRandom();

    drawMountain(130, "#8bb2bb");
    drawMountain(50, "#618087");
}
```

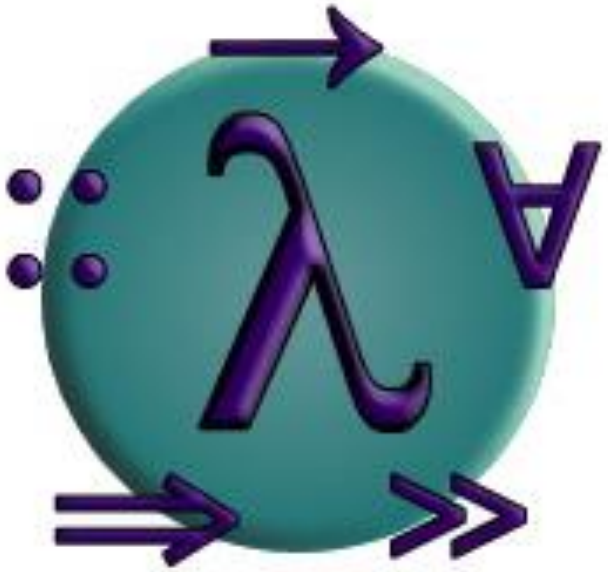
Spreadsheet are ‘live programming’ avant la lettre.

What Bret Victor is been advocating for lately, we had that since VisiCalc!

Just type up your formula and you will get the result immediately.

pure functional

You love pure functional languages?



Haskell

A Purely Functional Language

featuring static typing, higher-order functions, polymorphism, type classes and monadic effects

pure functional

Excel

A Purely Functional Language

featuring static typing, higher-order functions, polymorphism, type classes and monadic effects

You love pure functional languages?

We've got you covered. All a formula can do is take input and do something with it.

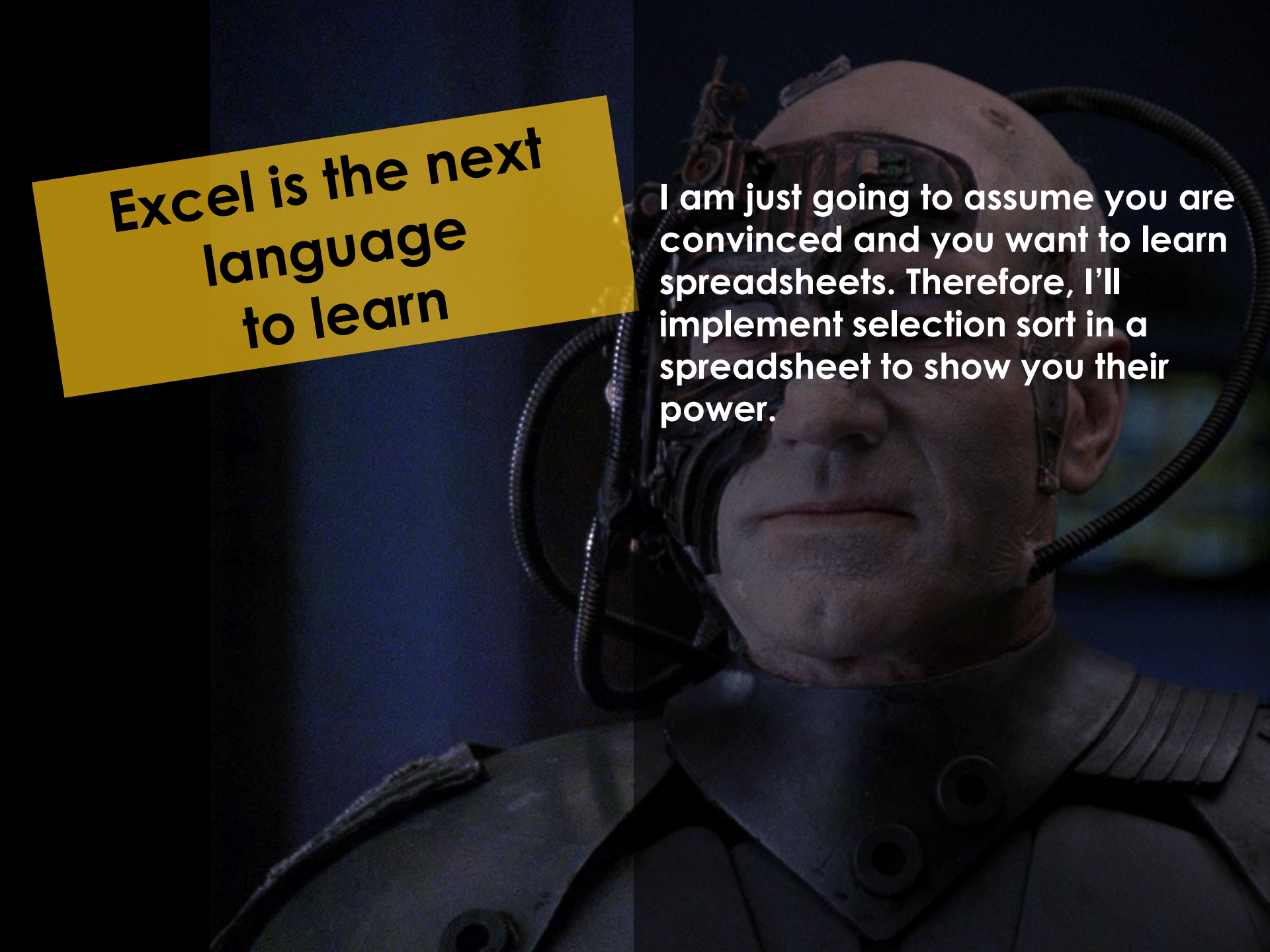
No side effects possible.

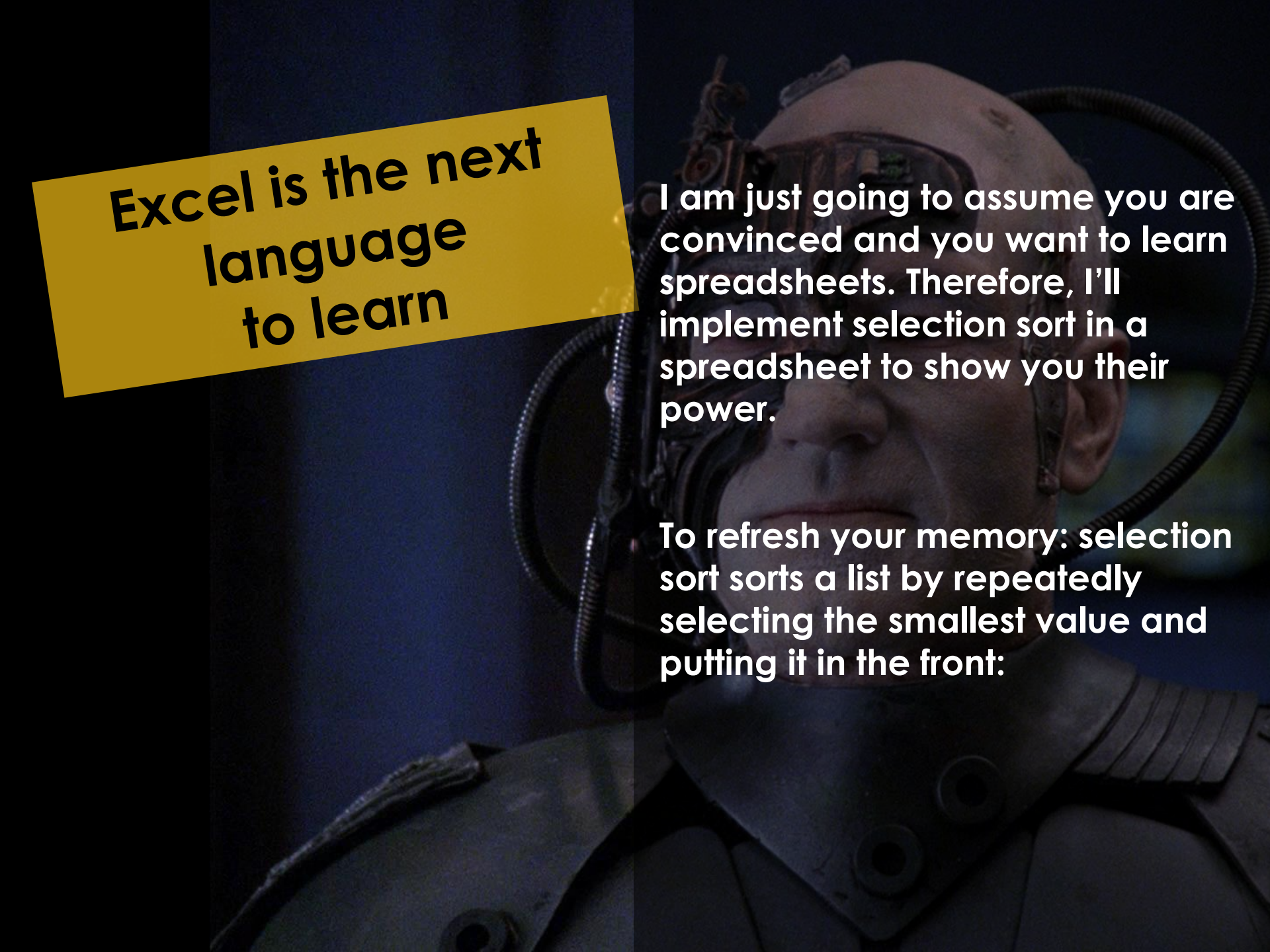
Lingua franca of computing

Finally, spreadsheets are the lingua franca of computing. You grandfather probably knows how to put a spreadsheet together for his savings. Your next door neighbour? Uses it for his fantasy football league. That history major you are helping out with his math work? I am sure he out-pivot tables you!

Everyone knows this, expect for developers!

That's just crazy!


Excel is the next language to learn
I am just going to assume you are convinced and you want to learn spreadsheets. Therefore, I'll implement selection sort in a spreadsheet to show you their power.



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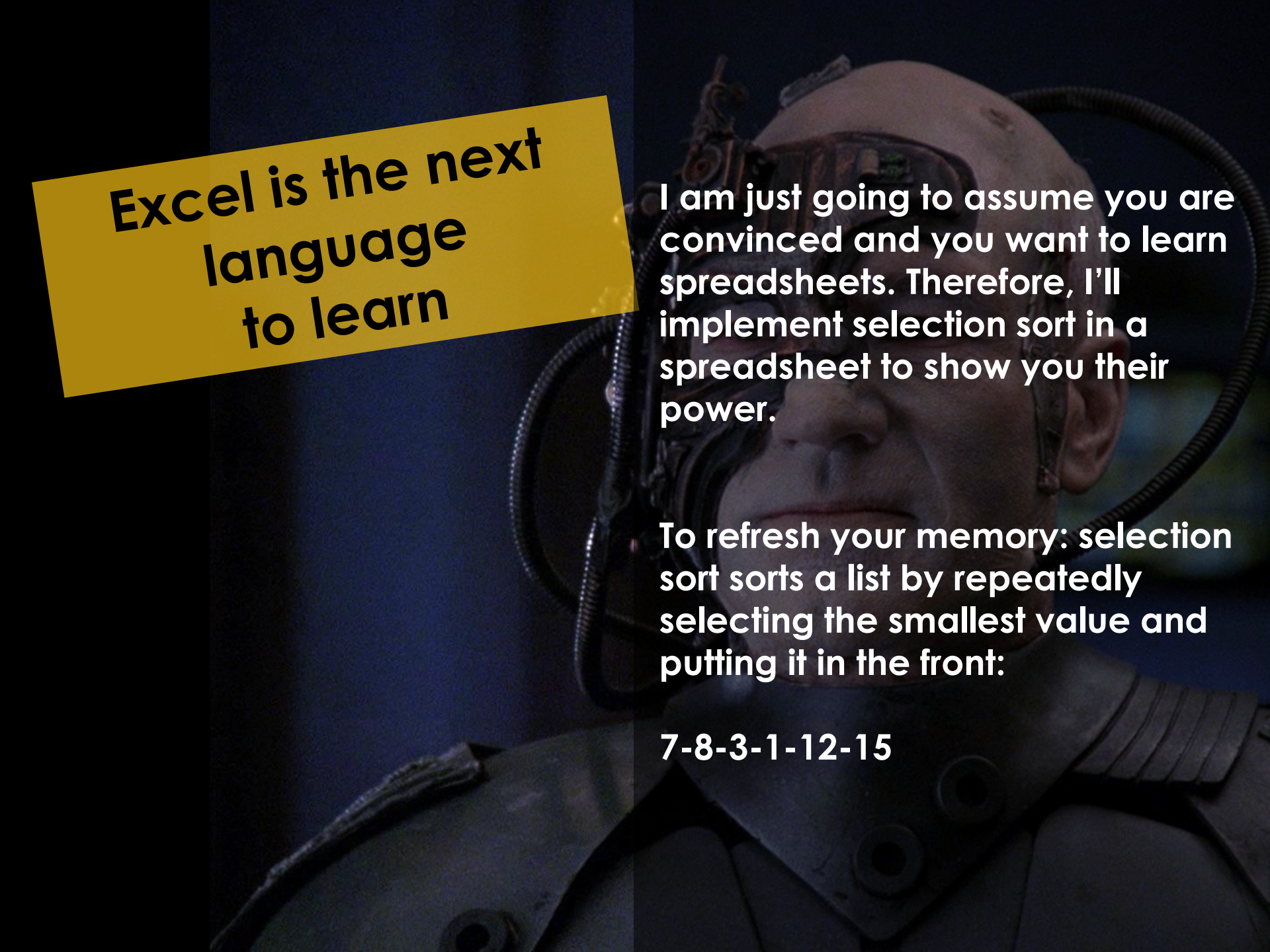
To refresh your memory: selection sort sorts a list by repeatedly selecting the smallest value and putting it in the front:



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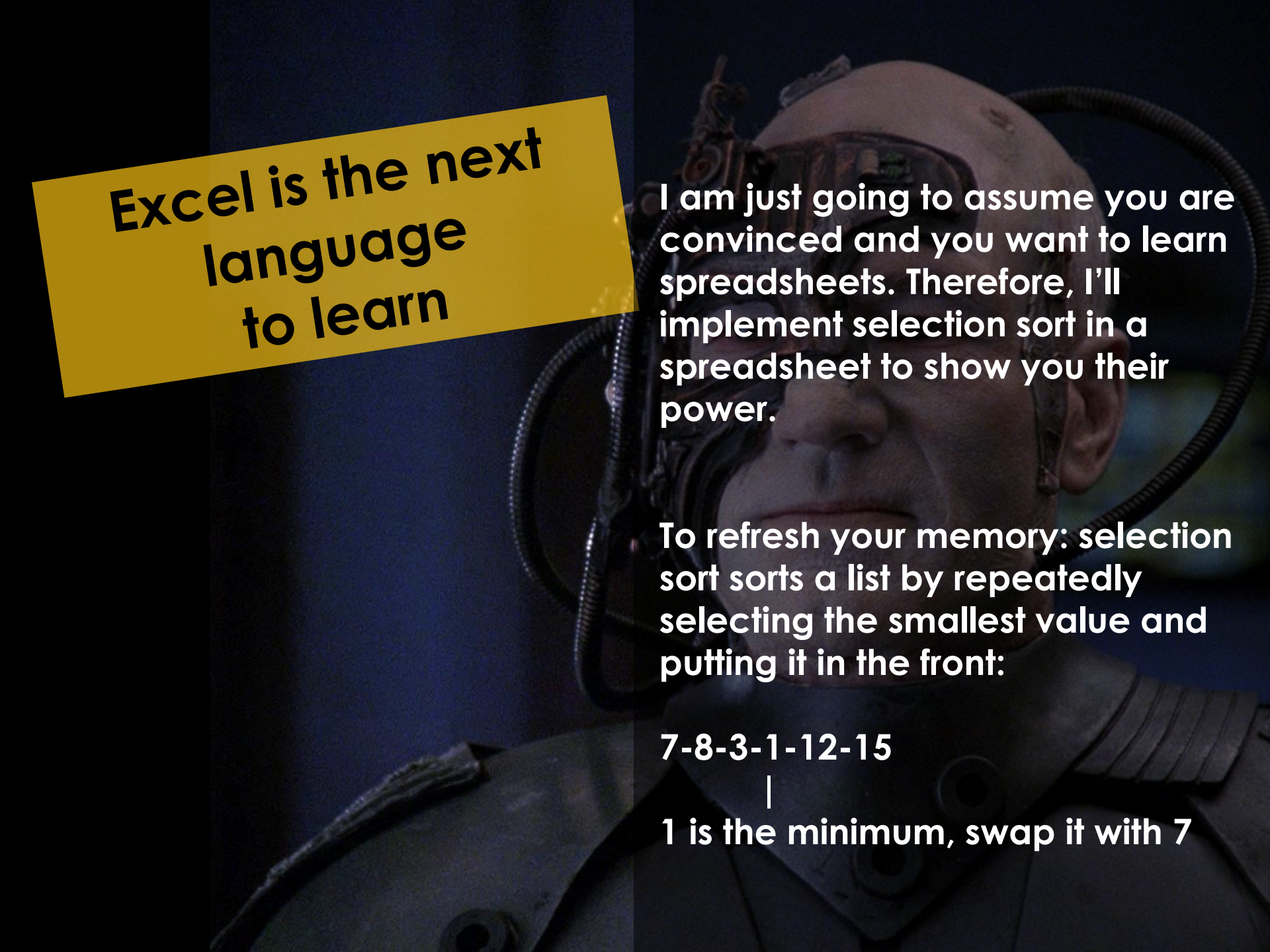
7-8-3-1-12-15



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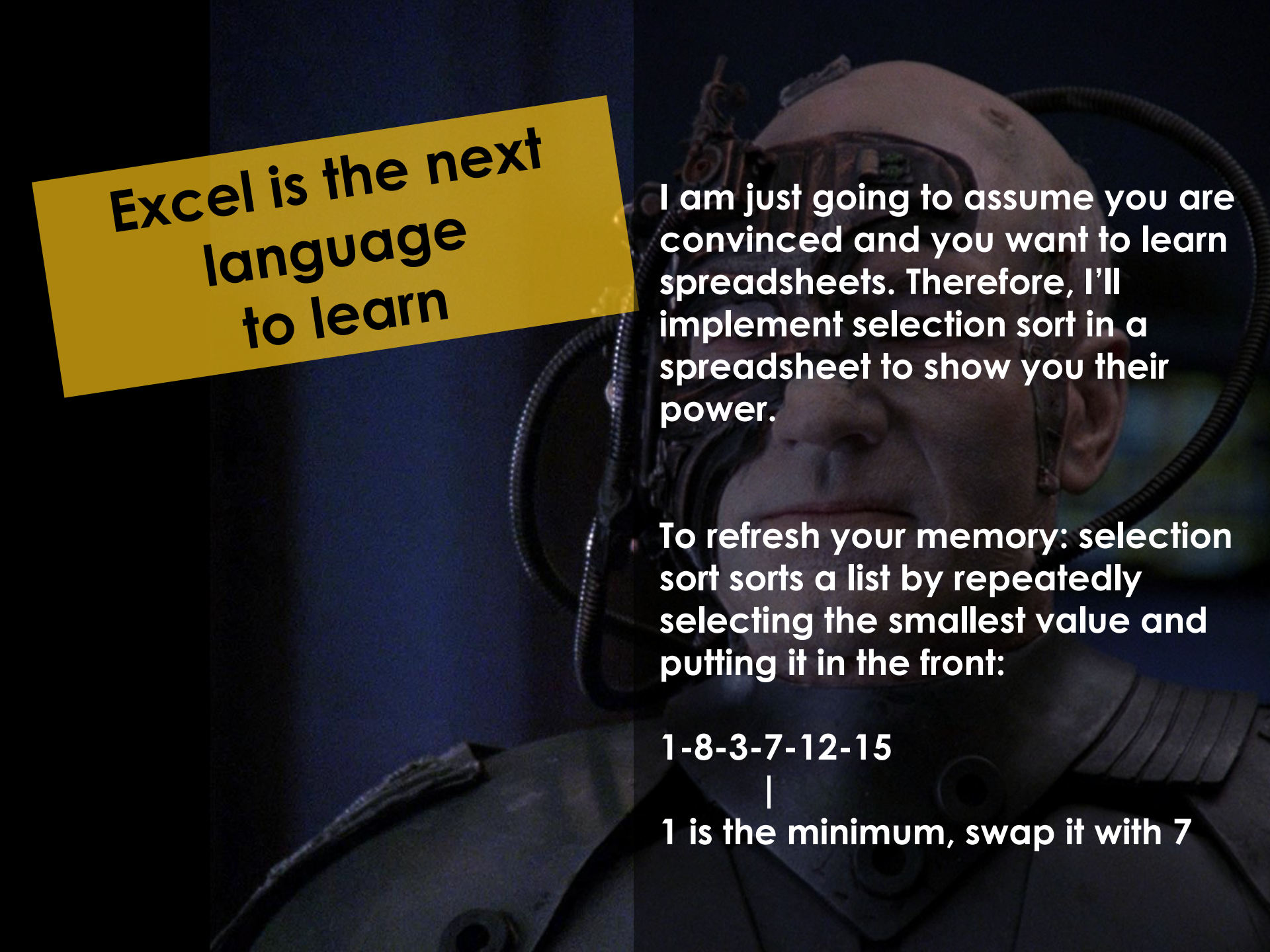
To refresh your memory: selection sort sorts a list by repeatedly selecting the smallest value and putting it in the front:

7-8-3-1-12-15
|
1 is the minimum, swap it with 7



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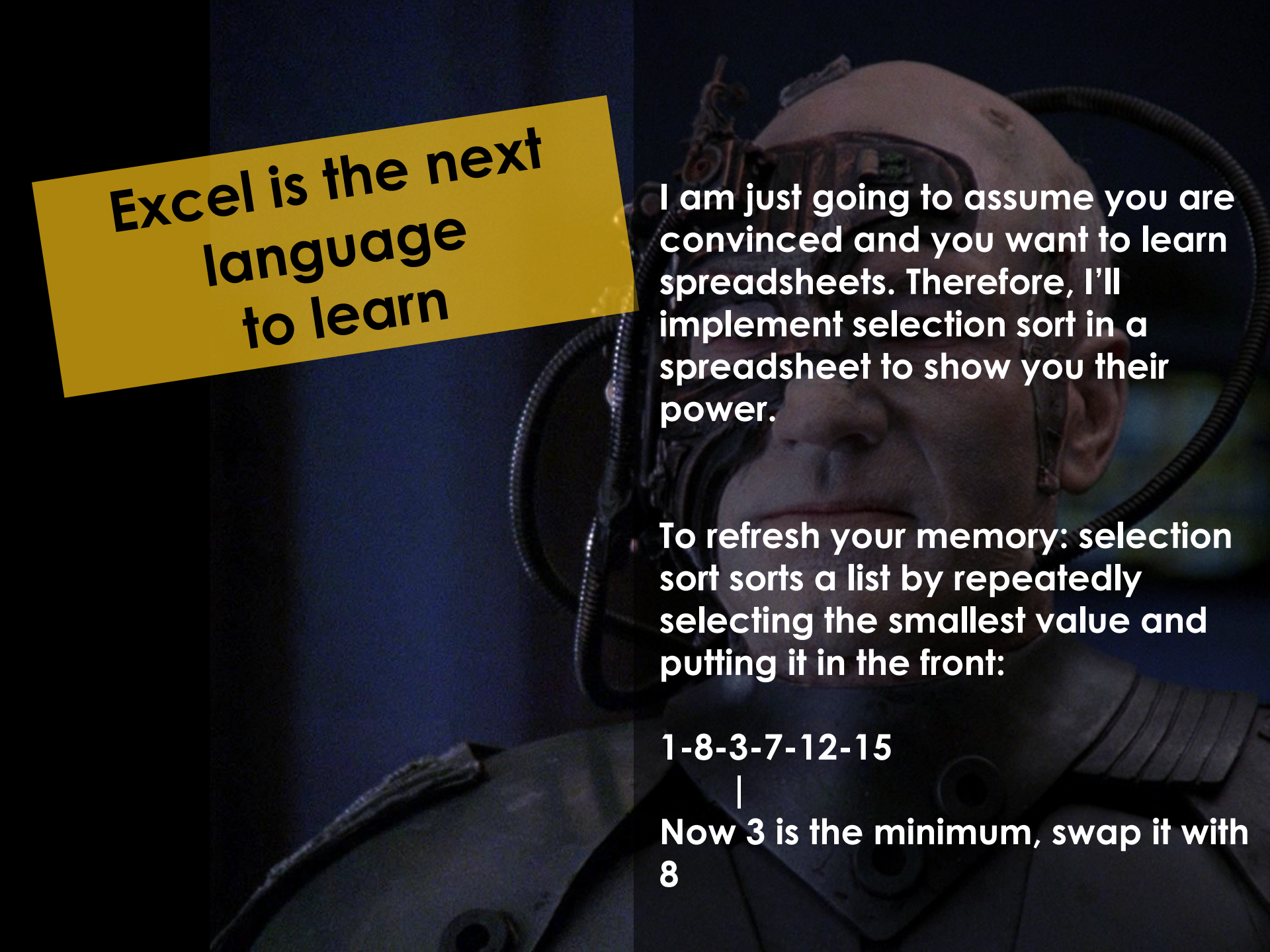
To refresh your memory: selection sort sorts a list by repeatedly selecting the smallest value and putting it in the front:

1-8-3-7-12-15
|
1 is the minimum, swap it with 7



Excel is the next language to learn

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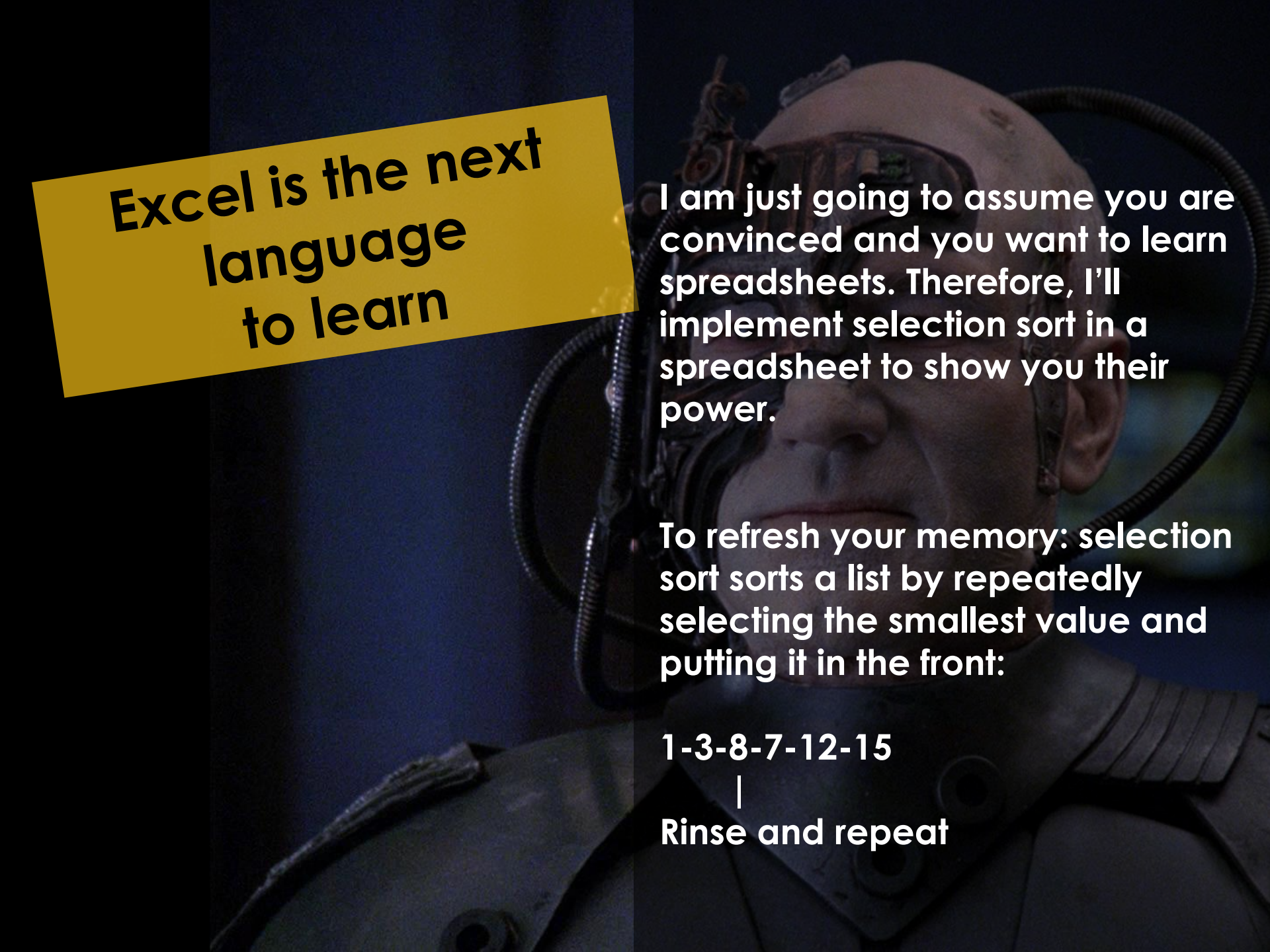
To refresh your memory: selection sort sorts a list by repeatedly selecting the smallest value and putting it in the front:

1-8-3-7-12-15
  |

Now 3 is the minimum, swap it with 8

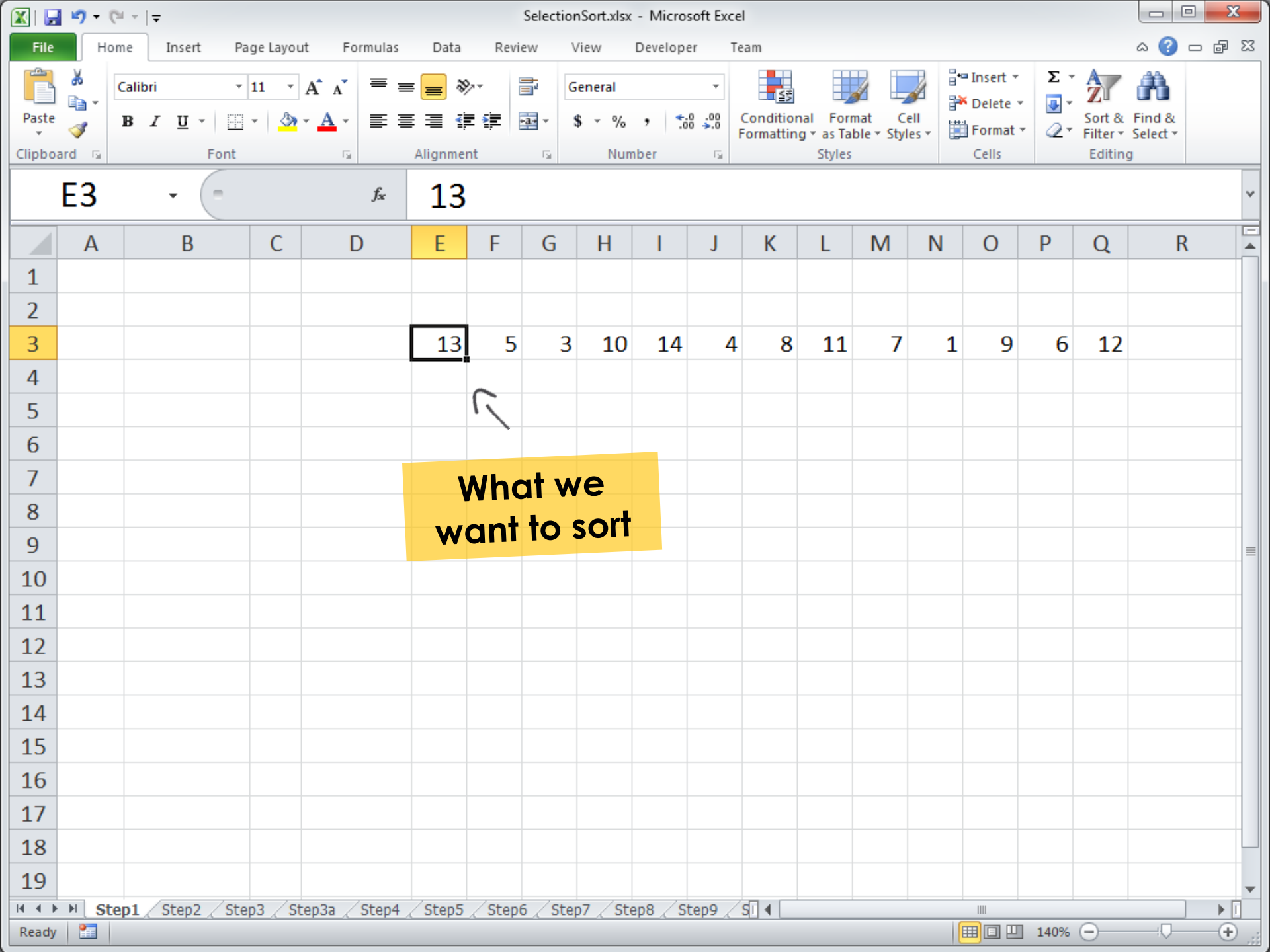


Excel is the next language to learn

I am just going to assume you are convinced and you want to learn spreadsheets. Therefore, I'll implement selection sort in a spreadsheet to show you their power.

To refresh your memory: selection sort sorts a list by repeatedly selecting the smallest value and putting it in the front:

1-3-8-7-12-15
|
Rinse and repeat


SelectionSort.xlsx - Microsoft Excel
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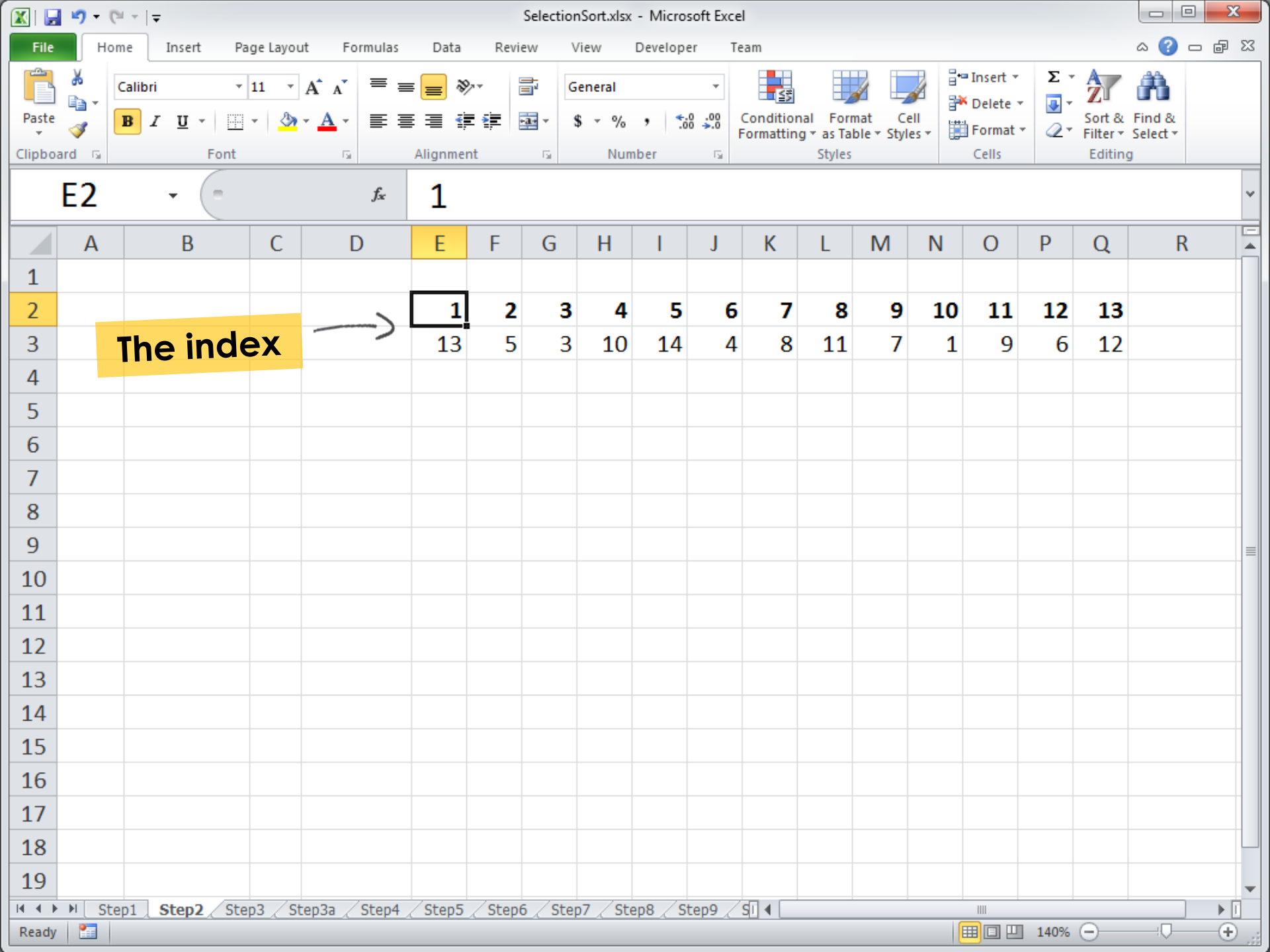
Conditional Formatting
Format as Table
Cell Styles
Styles
Insert
Delete
Format
Cells
Sort & Filter
Find & Select
Editing
E3
13
A B C D E F G H I J K L M N O P Q R
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
13 5 3 10 14 4 8 11 7 1 9 6 12
What we want to sort
Step1 Step2 Step3 Step3a Step4 Step5 Step6 Step7 Step8 Step9
Ready
140%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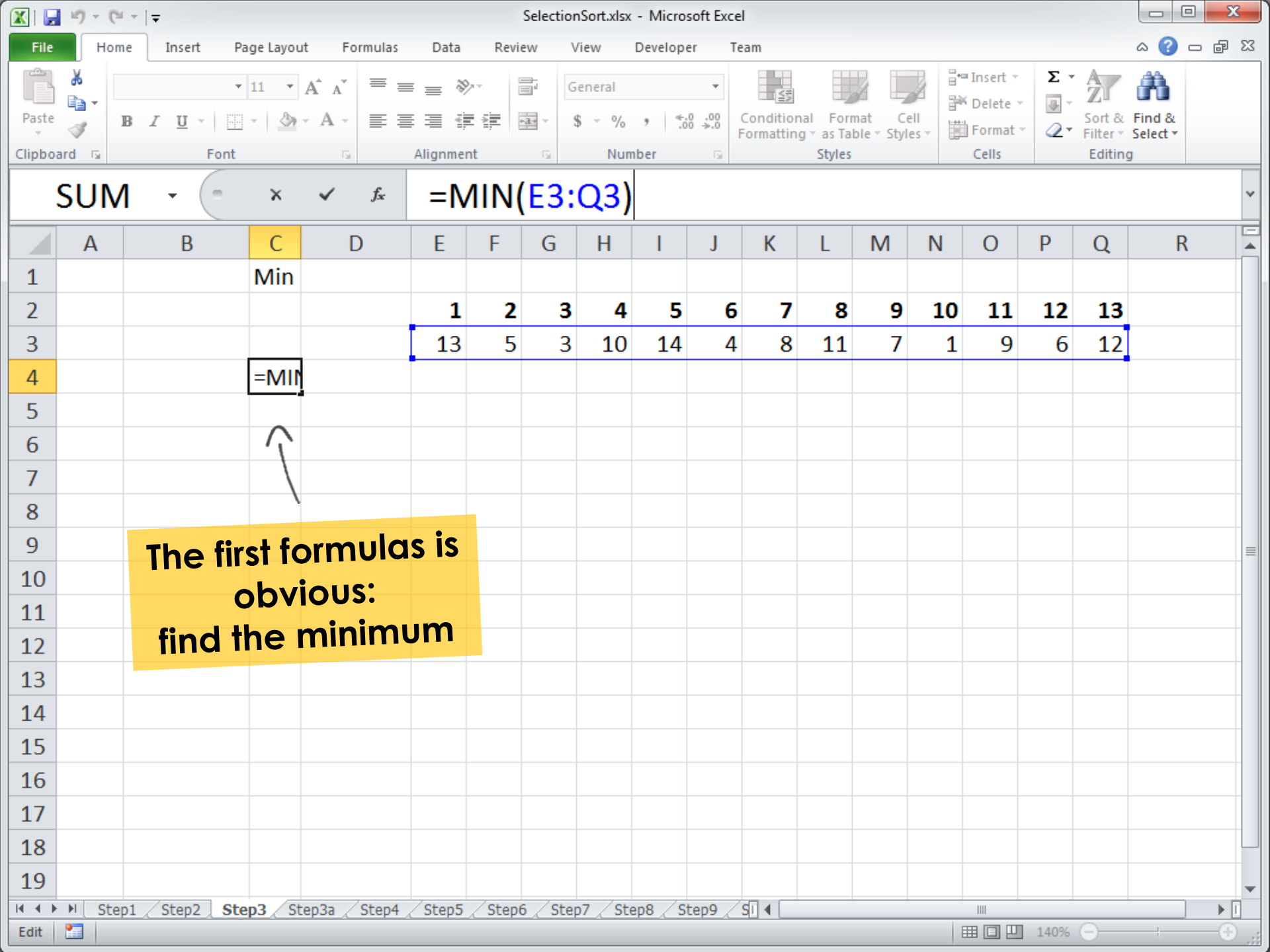
E2
1
The index
1 2 3 4 5 6 7 8 9 10 11 12 13
13 5 3 10 14 4 8 11 7 1 9 6 12
Step1
Step2
Step3
Step3a
Step4
Step5
Step6
Step7
Step8
Step9
Ready
140%


SelectionSort.xlsx - Microsoft Excel
File
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Insert
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Formulas
Data
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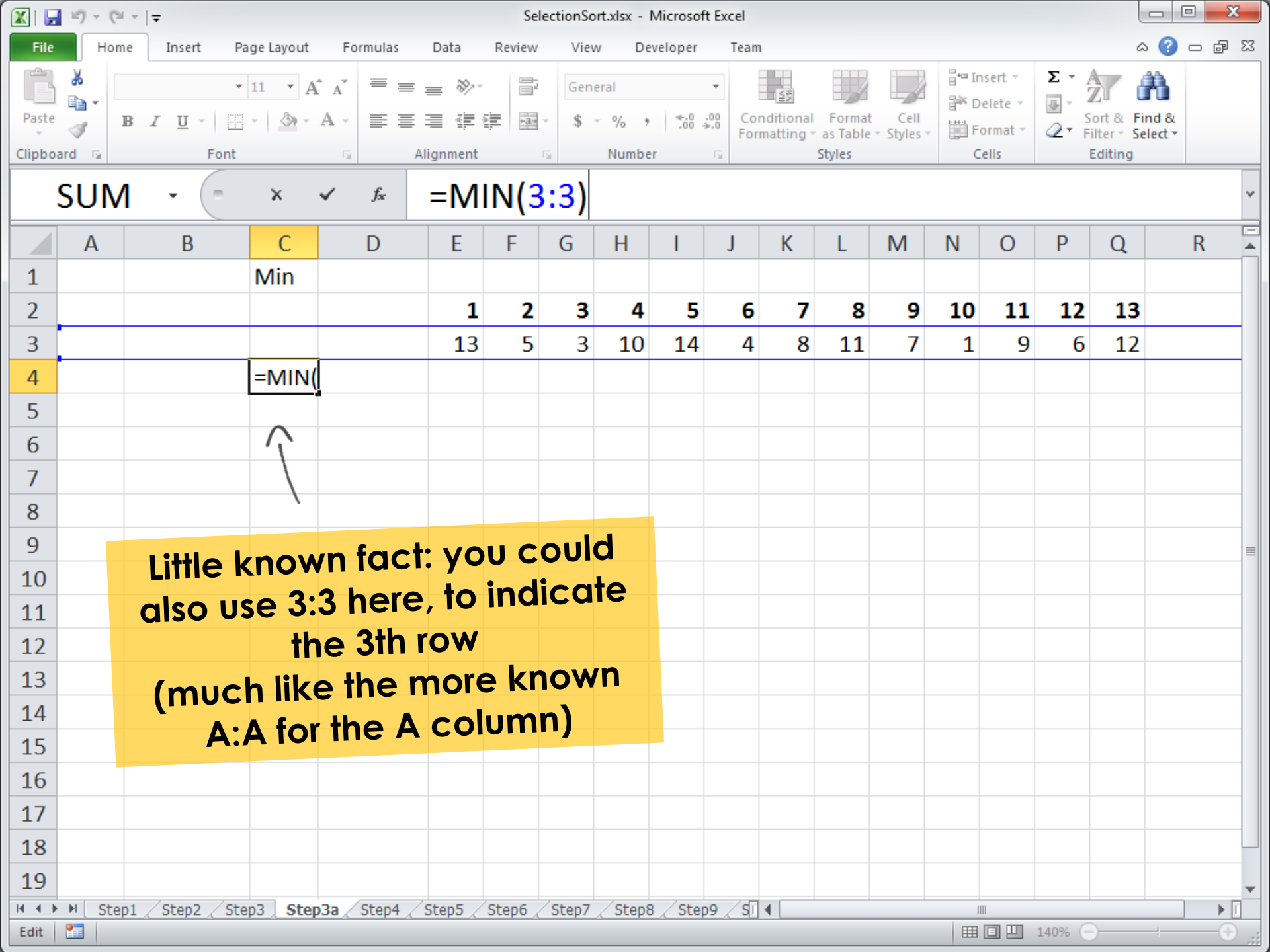
View
Developer
Team
SUM
=MIN(E3:Q3)
Min
1 2 3 4 5 6 7 8 9 10 11 12 13
13 5 3 10 14 4 8 11 7 1 9 6 12
=MIN
The first formulas is obvious:
find the minimum
Step1 Step2 Step3 Step3a Step4 Step5 Step6 Step7 Step8 Step9
Edit
140%


SelectionSort.xlsx - Microsoft Excel
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Data
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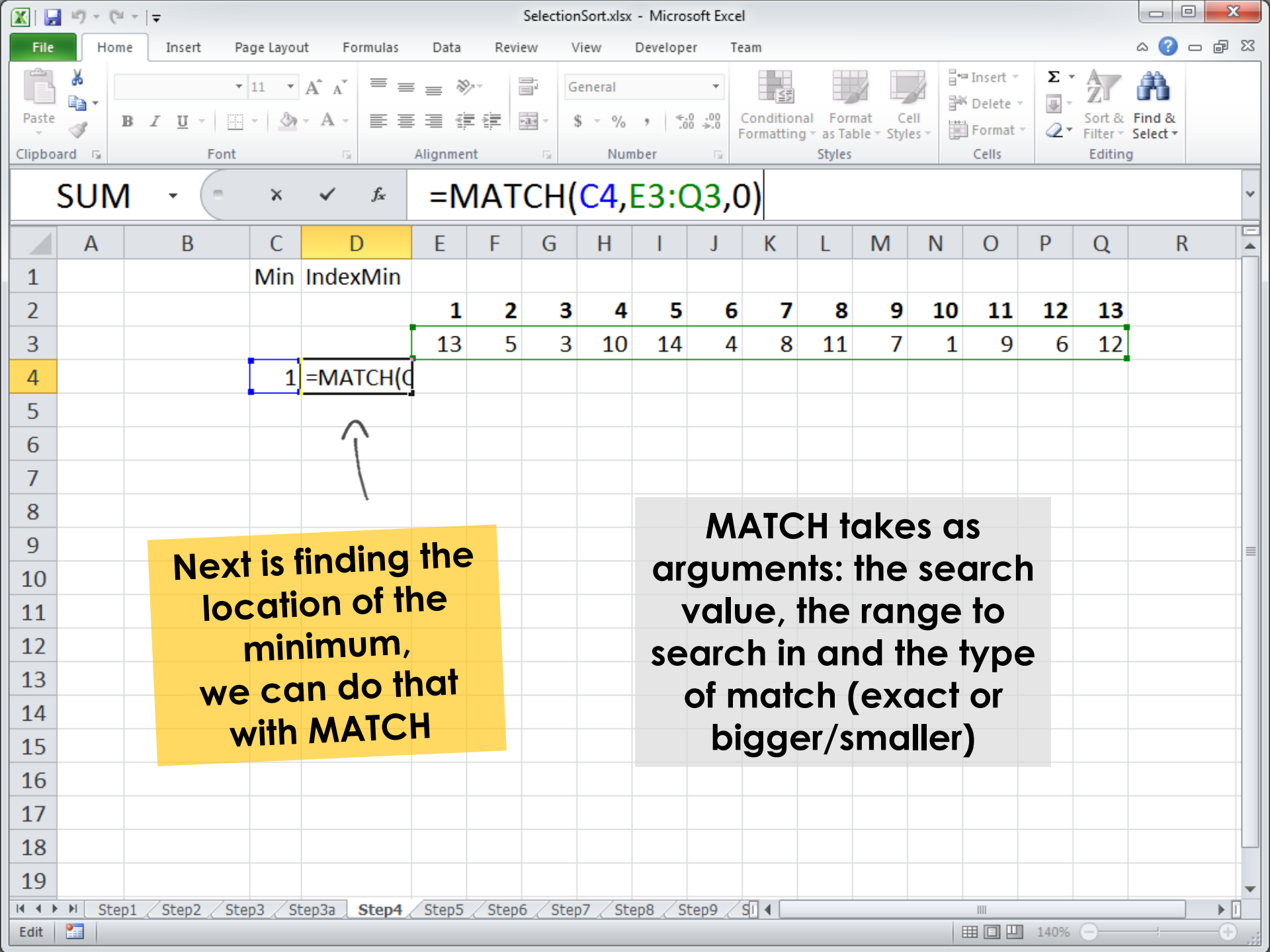
View
Developer
Team
SUM
=MIN(3:3)
Min
=MIN(
1 2 3 4 5 6 7 8 9 10 11 12 13
13 5 3 10 14 4 8 11 7 1 9 6 12
Little known fact: you could also use 3:3 here, to indicate the 3th row
(much like the more known A:A for the A column)
Step1 Step2 Step3 Step3a Step4 Step5 Step6 Step7 Step8 Step9
Edit
140%


SelectionSort.xlsx - Microsoft Excel
File
Home
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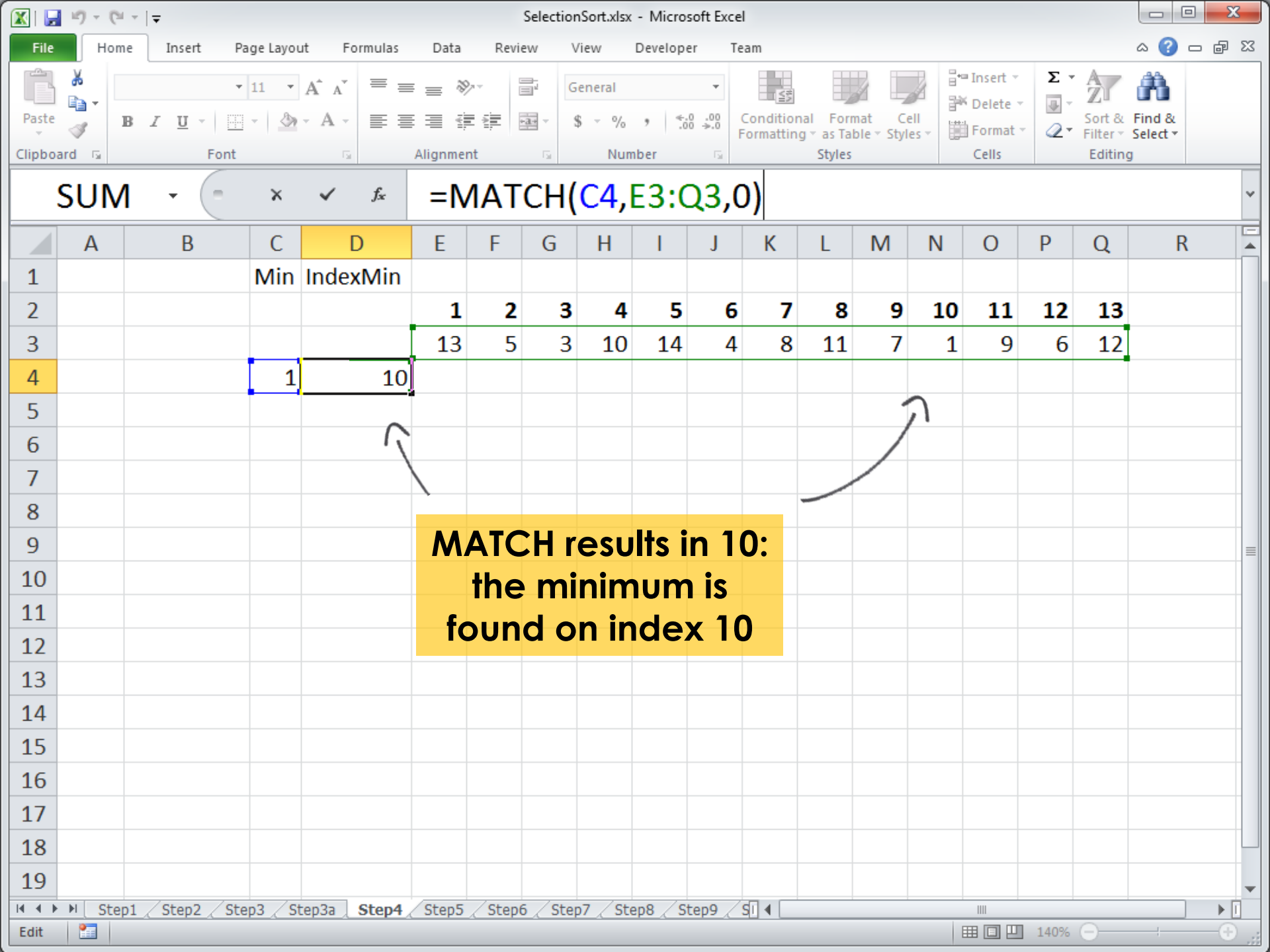
View
Developer
Team
SUM
=MATCH(C4,E3:Q3,0)
Min
IndexMin
1 2 3 4 5 6 7 8 9 10 11 12 13
13 5 3 10 14 4 8 11 7 1 9 6 12
1
=MATCH(C
Next is finding the location of the minimum, we can do that with MATCH
MATCH takes as arguments: the search value, the range to search in and the type of match (exact or bigger/smaller)
Step1 Step2 Step3 Step3a Step4 Step5 Step6 Step7 Step8 Step9
Edit
140%


SelectionSort.xlsx - Microsoft Excel
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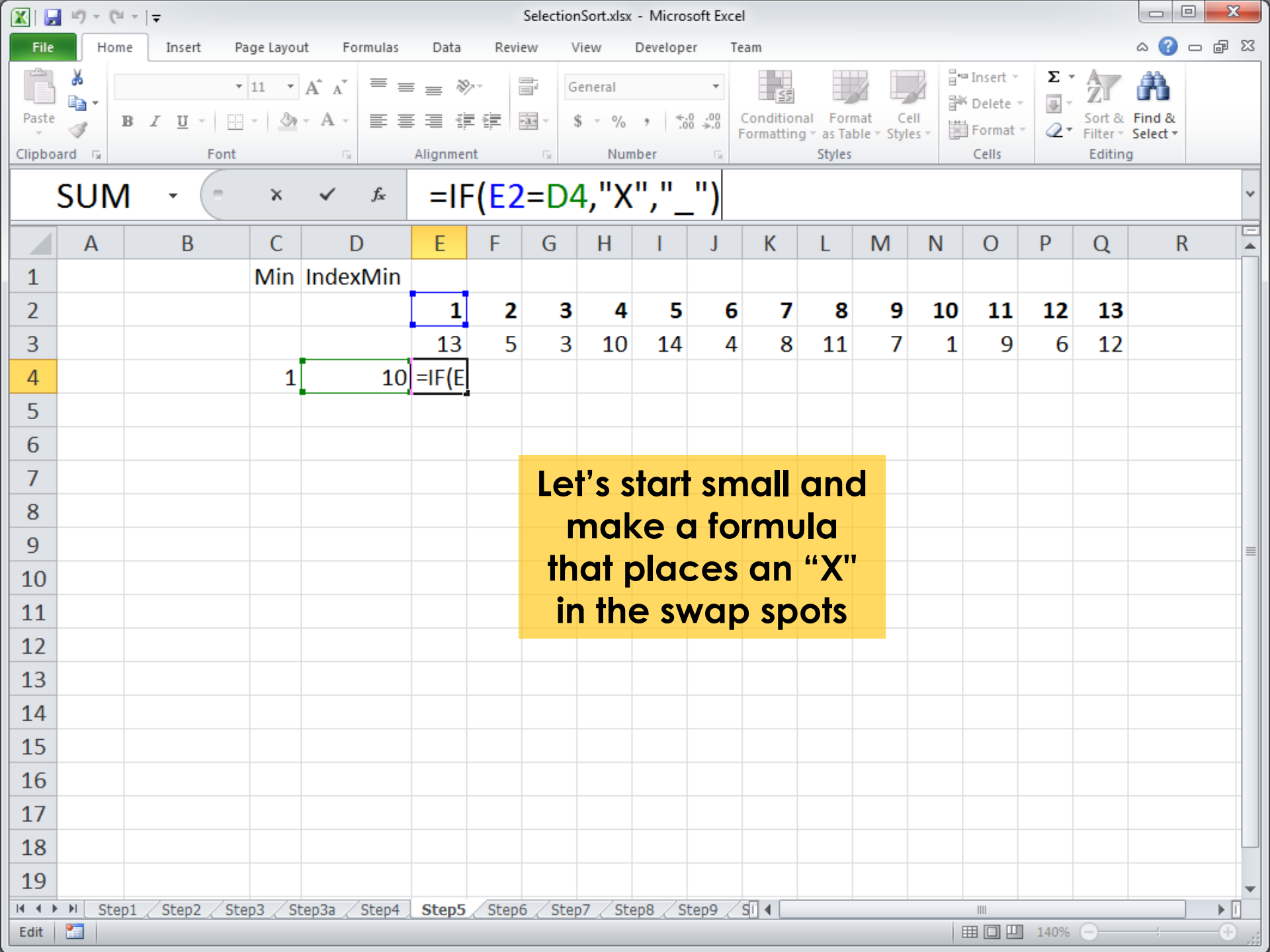
Formulas
Data
Review
View
Developer
Team
SUM
=MATCH(C4,E3:Q3,0)
Min
IndexMin
1
2
3
4
5
6
7
8
9
10
11
12
13
13
5
3
10
14
4
8
11
7
1
9
6
12
1
10
MATCH results in 10: the minimum is found on index 10
Step1
Step2
Step3
Step3a
Step4
Step5
Step6
Step7
Step8
Step9
Edit
140%


SelectionSort.xlsx - Microsoft Excel
File
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Formulas
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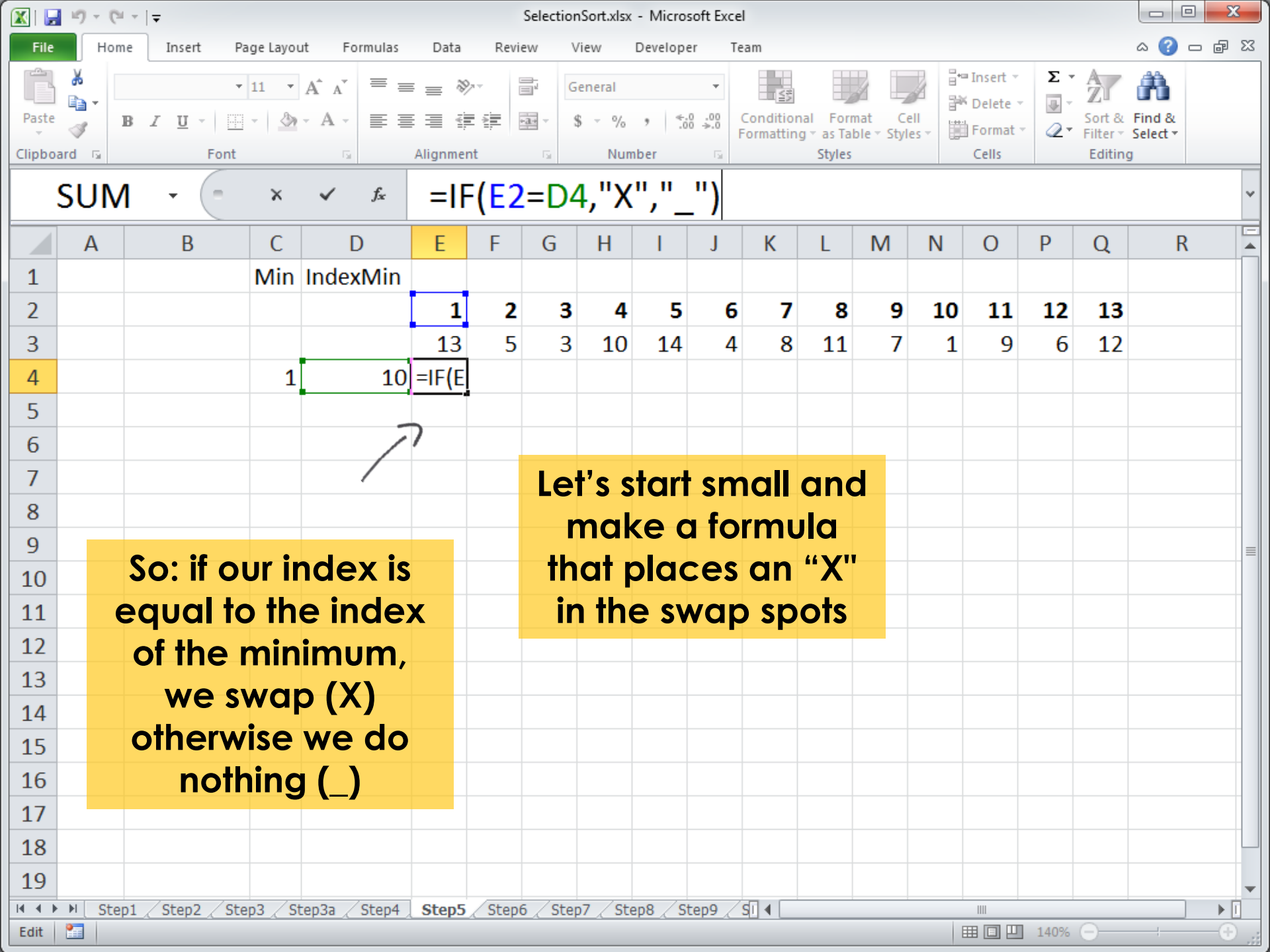
Developer
Team
SUM
=IF(E2=D4,"X","_")
Min
IndexMin
1
2
3
4
5
6
7
8
9
10
11
12
13
13
5
3
10
14
4
8
11
7
1
9
6
12
1
10
=IF(E
Let's start small and make a formula that places an "X" in the swap spots
Step1
Step2
Step3
Step3a
Step4
Step5
Step6
Step7
Step8
Step9
Edit
140%


SelectionSort.xlsx - Microsoft Excel
File
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Insert
Page Layout
Formulas
Data
Review
View
Developer
Team
SUM
=IF(E2=D4,"X","_")
Min
IndexMin
1 2 3 4 5 6 7 8 9 10 11 12 13
13 5 3 10 14 4 8 11 7 1 9 6 12
1
10
=IF(E
So: if our index is equal to the index of the minimum, we swap (X) otherwise we do nothing (_)
Let's start small and make a formula that places an "X" in the swap spots
Step1 Step2 Step3 Step3a Step4 Step5 Step6 Step7 Step8 Step9
Edit
140%

SelectionSort.xlsx - Microsoft Excel

File | Home | Insert | Page Layout | Formulas | Data | Review | View | Developer | Team

SUM

=IF(E2=D4,"X","_")

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
1			Min	IndexMin														
2					1	2	3	4	5	6	7	8	9	10	11	12	13	
3					13	5	3	10	14	4	8	11	7	1	9	6	12	
4			1	10	=IF(E													

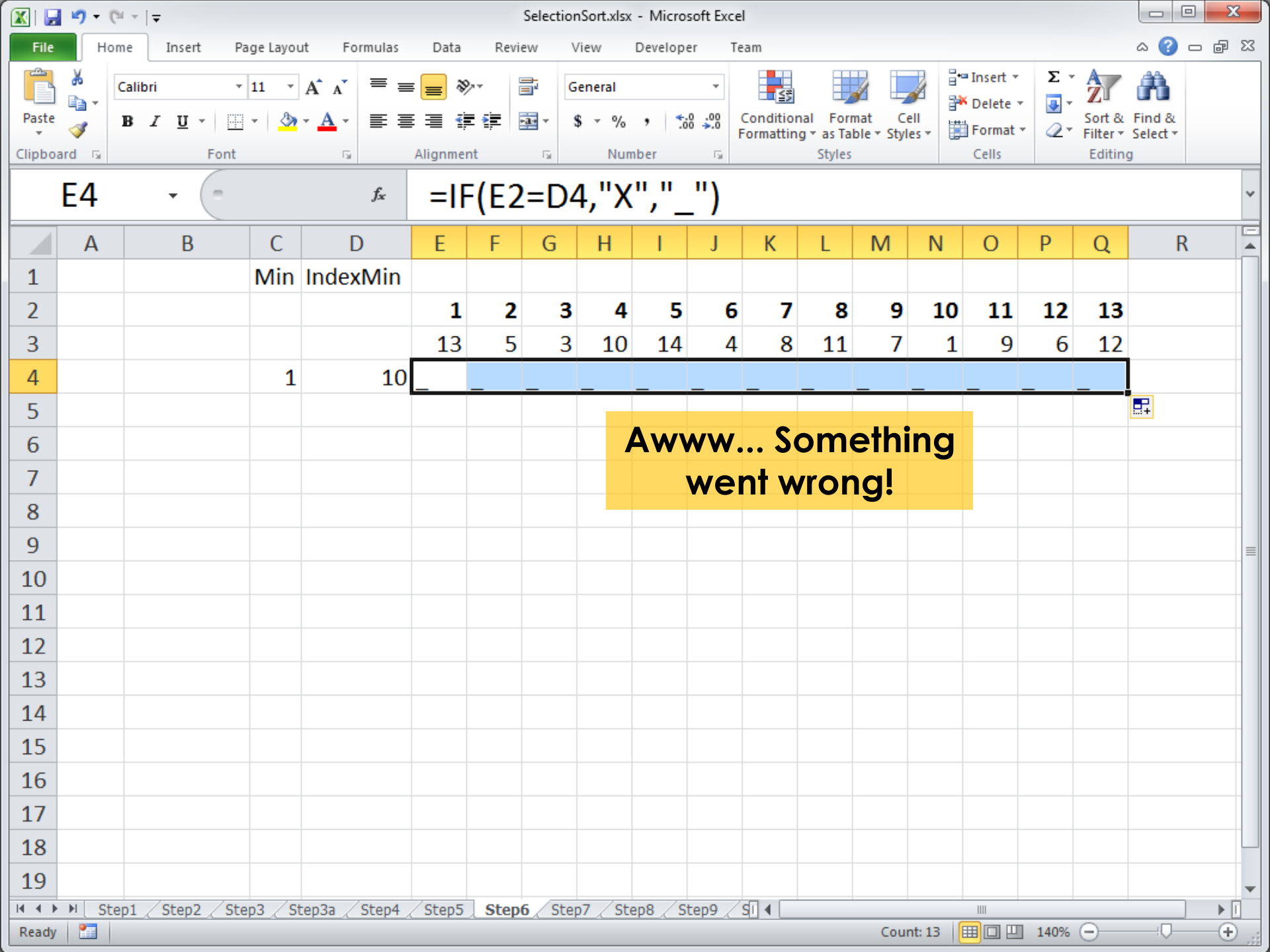
That looks cool, let's drag it right

So: if our index is equal to the index of the minimum, we swap (X) otherwise we do nothing (_)

Step1 | Step2 | Step3 | Step3a | Step4 | Step5 | Step6 | Step7 | Step8 | Step9

Edit

140%


SelectionSort.xlsx - Microsoft Excel
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Calibri
11
General
Conditional Formatting
Format as Table
Cell Styles
Insert
Delete
Format
Sort & Filter
Find & Select
Clipboard
Font
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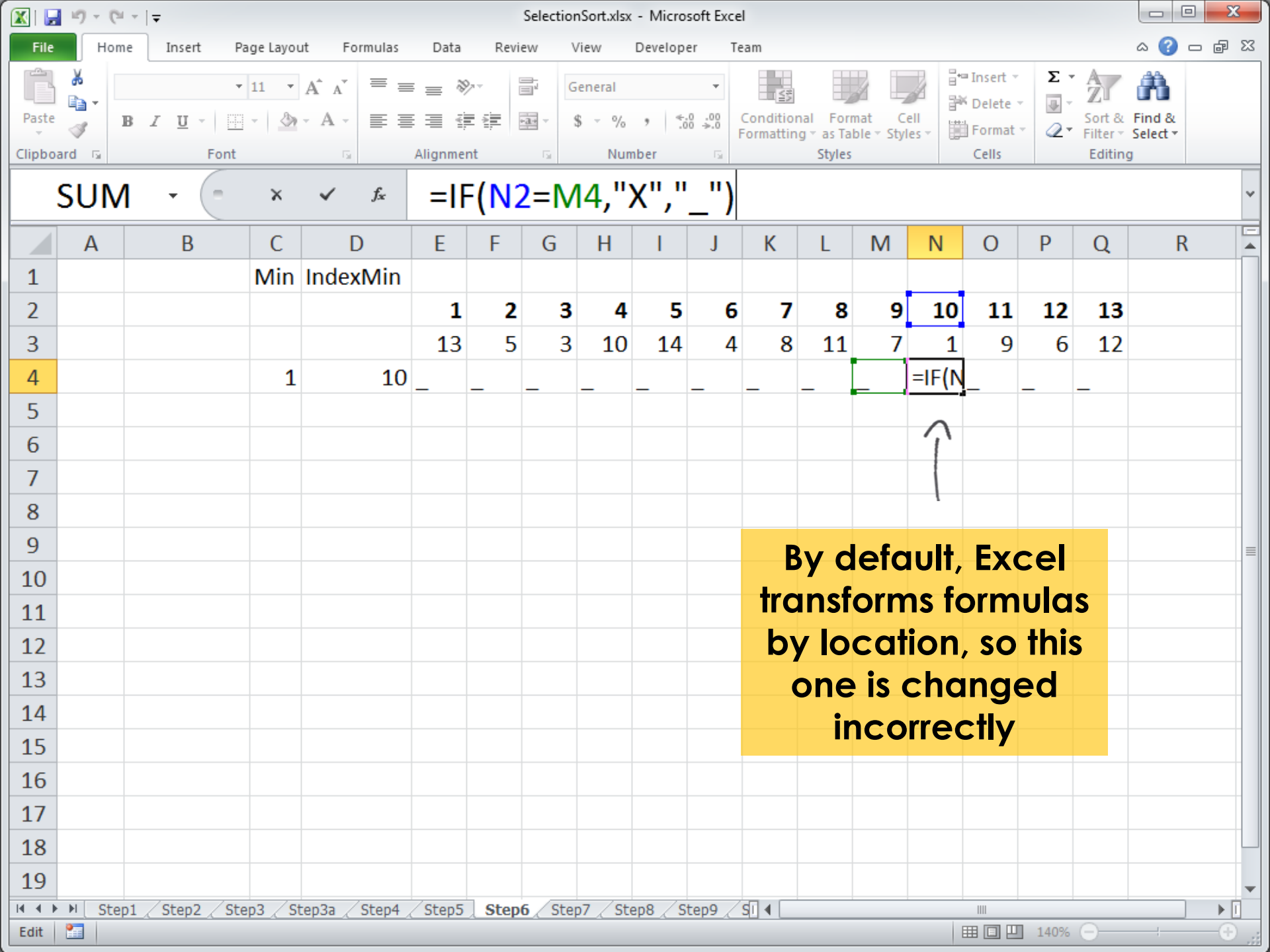
Number
Styles
Cells
Editing
E4
=IF(E2=D4,"X","_")
Min
IndexMin
1
10
1 2 3 4 5 6 7 8 9 10 11 12 13
13 5 3 10 14 4 8 11 7 1 9 6 12
Awww... Something went wrong!
Step1
Step2
Step3
Step3a
Step4
Step5
Step6
Step7
Step8
Step9
Ready
Count: 13
140%


SelectionSort.xlsx - Microsoft Excel
File
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Formulas
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SUM
=IF(N2=M4,"X","_")
Min
IndexMin
1
10
1 2 3 4 5 6 7 8 9 10 11 12 13
13 5 3 10 14 4 8 11 7 1 9 6 12
=IF(N
By default, Excel transforms formulas by location, so this one is changed incorrectly
Step1 Step2 Step3 Step3a Step4 Step5 Step6 Step7 Step8 Step9
Edit
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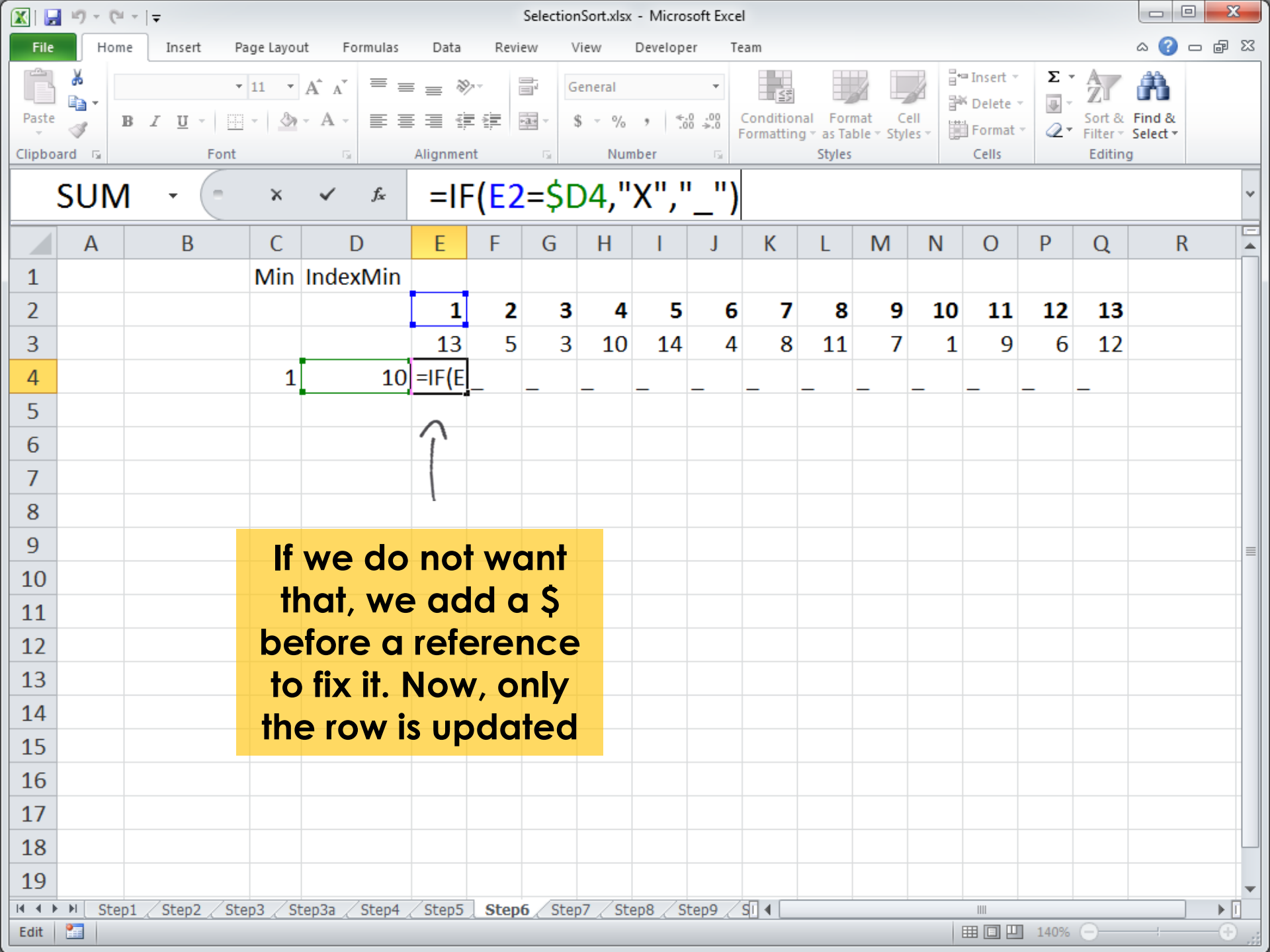
SelectionSort.xlsx - Microsoft Excel
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Developer
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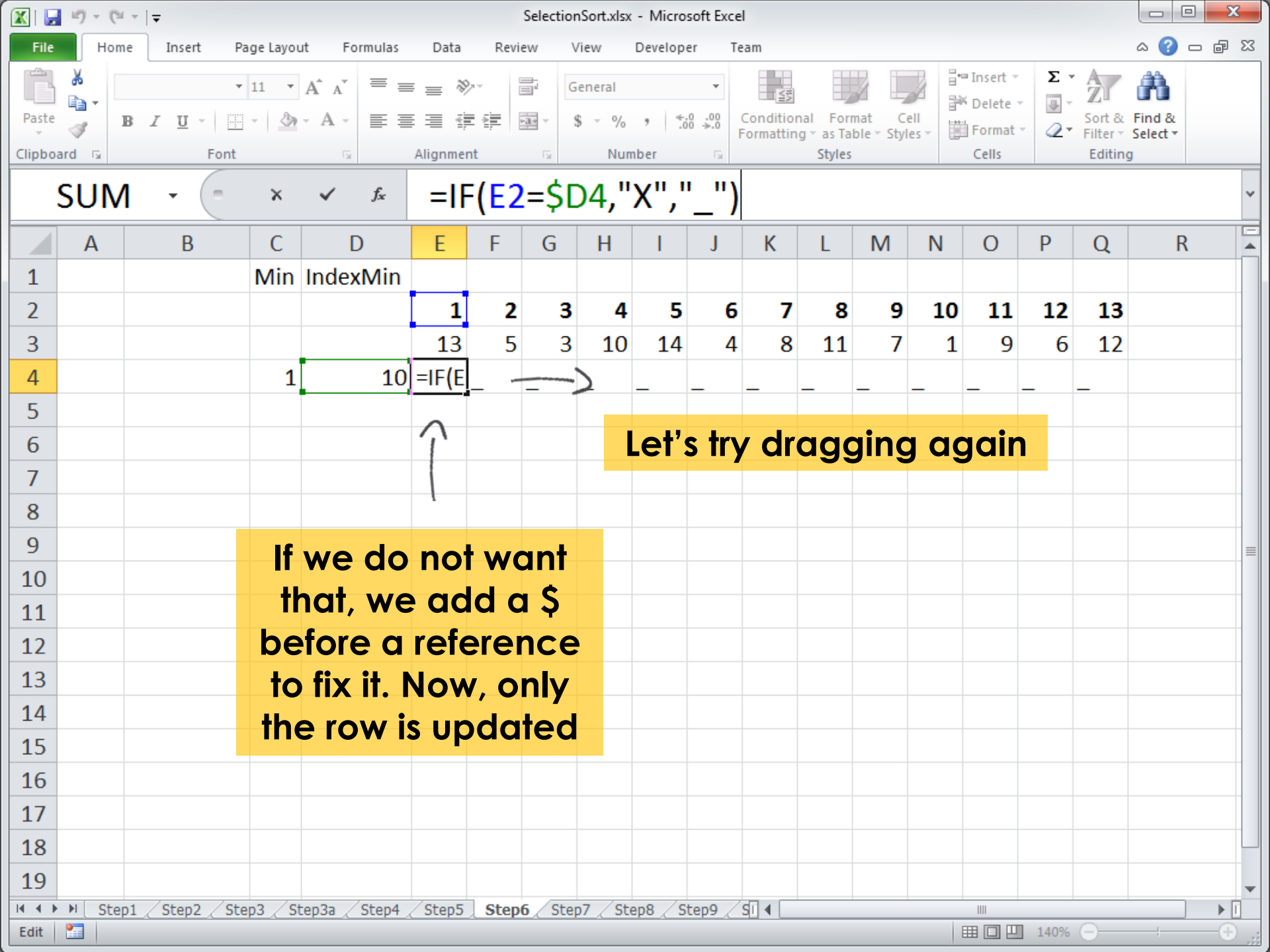
SUM
=IF(E2=$D4,"X","_")
Min
IndexMin
1 2 3 4 5 6 7 8 9 10 11 12 13
13 5 3 10 14 4 8 11 7 1 9 6 12
1 10 =IF(E
If we do not want that, we add a $ before a reference to fix it. Now, only the row is updated
Step1 Step2 Step3 Step3a Step4 Step5 Step6 Step7 Step8 Step9
Edit
140%


SelectionSort.xlsx - Microsoft Excel
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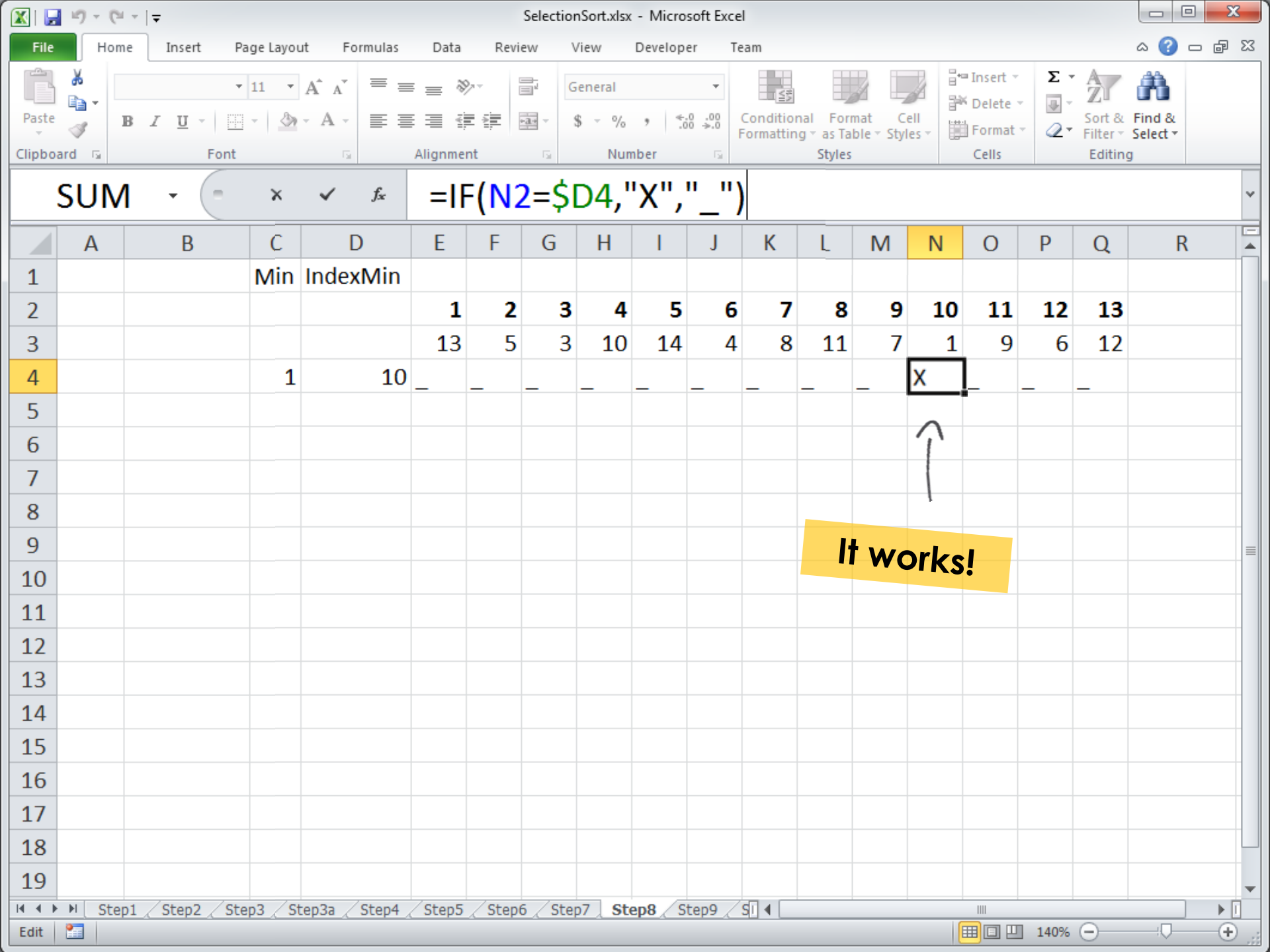
View
Developer
Team
SUM
=IF(E2=$D4,"X","_")
Min
IndexMin
1 2 3 4 5 6 7 8 9 10 11 12 13
13 5 3 10 14 4 8 11 7 1 9 6 12
1
10
=IF(E
Let's try dragging again
If we do not want that, we add a $ before a reference to fix it. Now, only the row is updated
Step1 Step2 Step3 Step3a Step4 Step5 Step6 Step7 Step8 Step9
Edit
140%


SelectionSort.xlsx - Microsoft Excel
File
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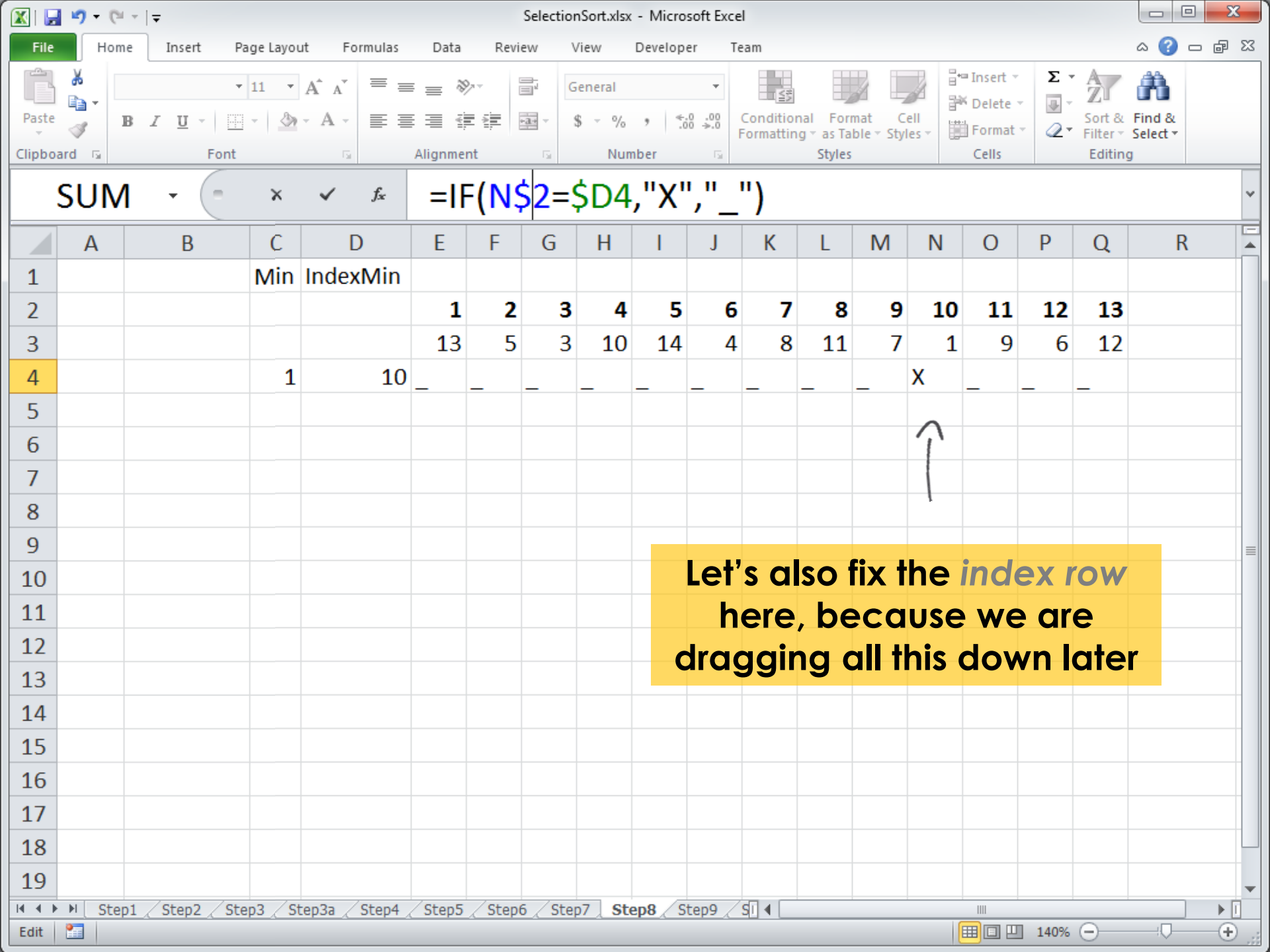
Insert
Page Layout
Formulas
Data
Review
View
Developer
Team
SUM
=IF(N2=$D4,"X","_")
Min
IndexMin
1
10
1 2 3 4 5 6 7 8 9 10 11 12 13
13 5 3 10 14 4 8 11 7 1 9 6 12
X
It works!
Step1
Step2
Step3
Step3a
Step4
Step5
Step6
Step7
Step8
Step9
Edit
140%


SelectionSort.xlsx - Microsoft Excel
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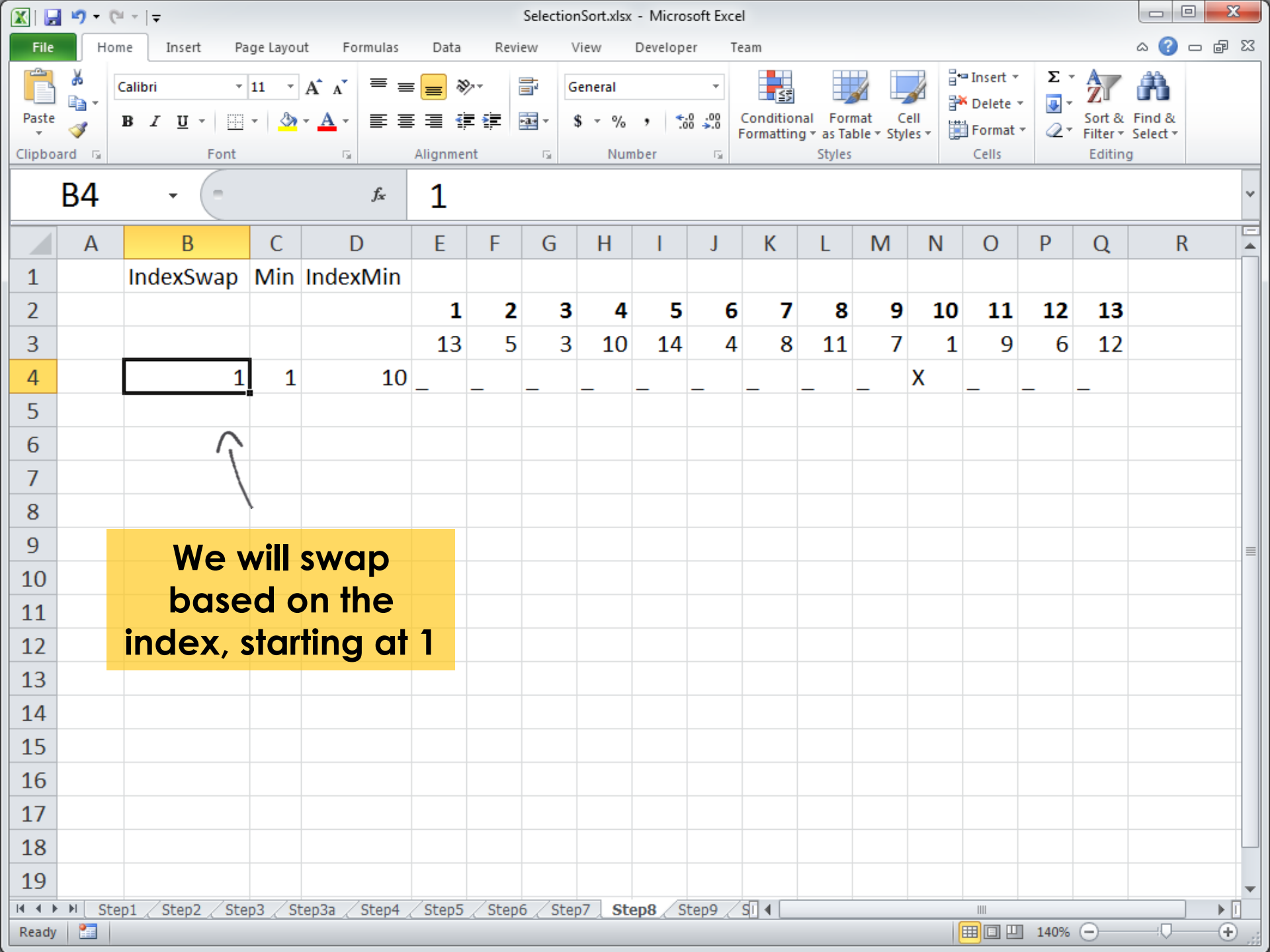
Conditional Formatting
Format as Table
Cell Styles
Styles
Insert
Delete
Format
Cells
Sort & Filter
Find & Select
Editing
SUM
=IF(N$2=$D4,"X","_")
Min
IndexMin
1
10
1 2 3 4 5 6 7 8 9 10 11 12 13
13 5 3 10 14 4 8 11 7 1 9 6 12
_ _ _ _ _ _ _ _ _ X _ _ _
Let's also fix the index row here, because we are dragging all this down later
Step1
Step2
Step3
Step3a
Step4
Step5
Step6
Step7
Step8
Step9
Edit
140%


SelectionSort.xlsx - Microsoft Excel
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General
Conditional Formatting
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Cell Styles
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Format
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Find & Select
Clipboard
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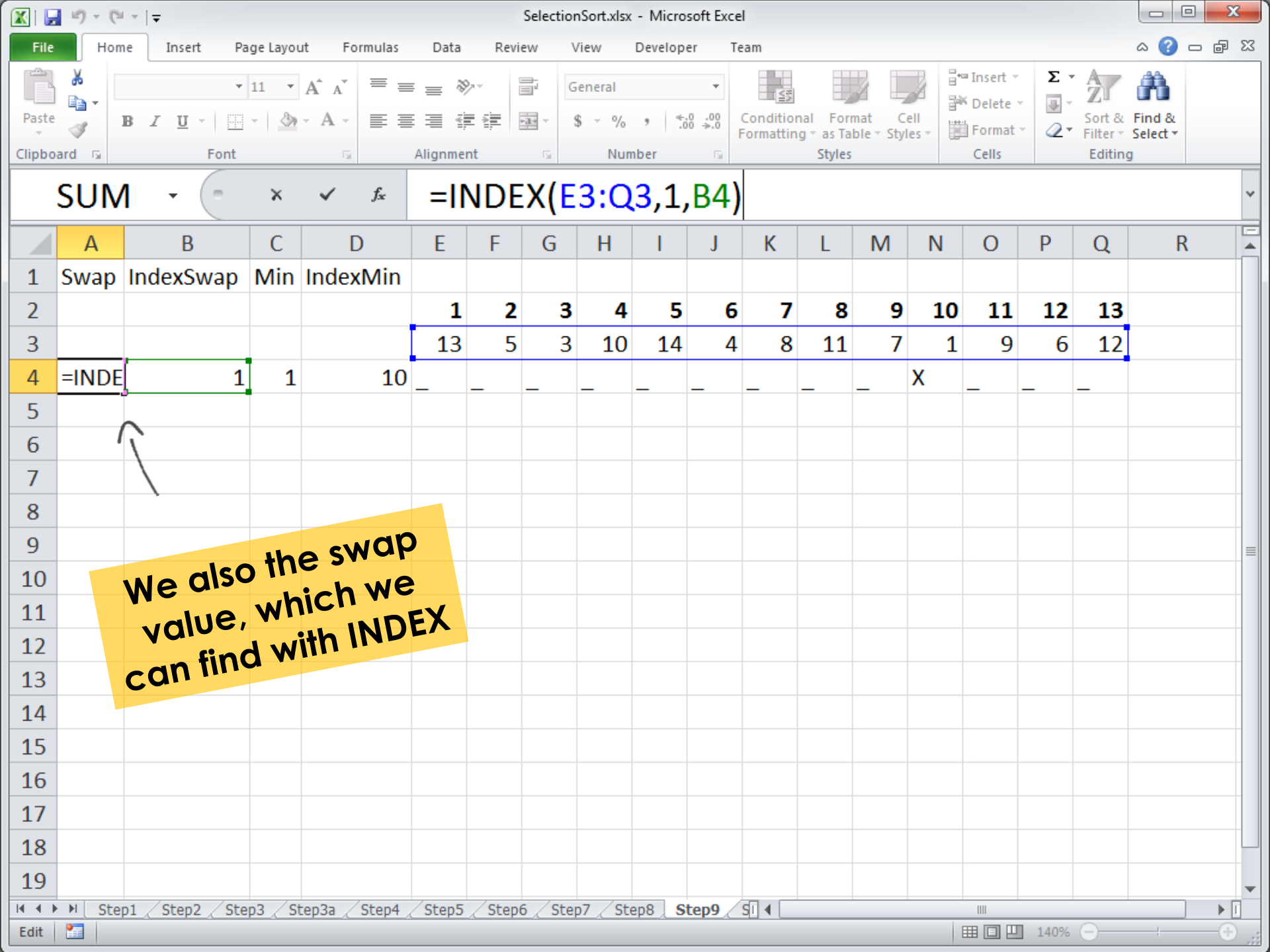
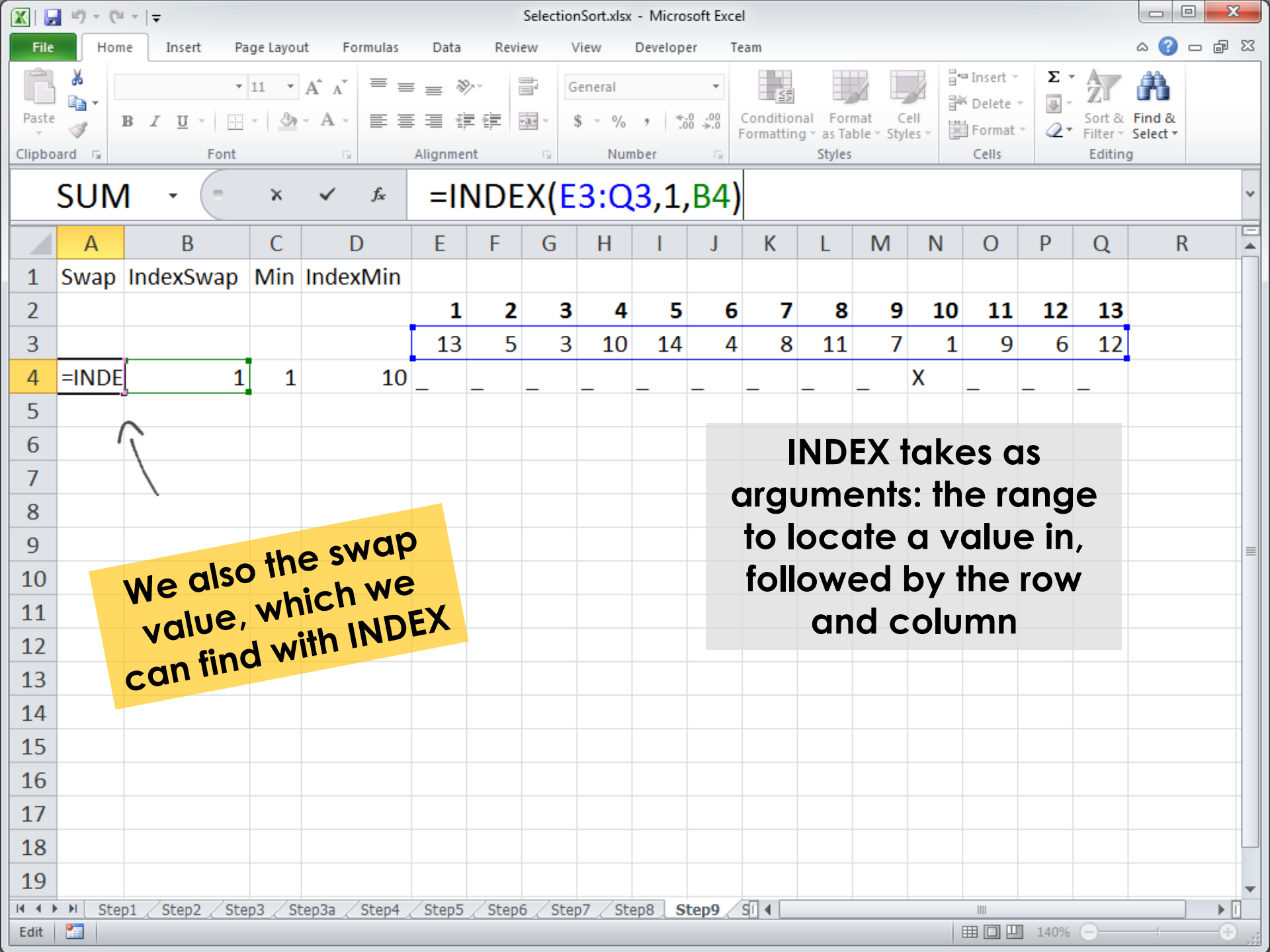
Number
Styles
Cells
Editing
B4
1
IndexSwap
Min
IndexMin
1 2 3 4 5 6 7 8 9 10 11 12 13
13 5 3 10 14 4 8 11 7 1 9 6 12
1 1 10
X
We will swap based on the index, starting at 1
Step1
Step2
Step3
Step3a
Step4
Step5
Step6
Step7
Step8
Step9
Ready
140%


SelectionSort.xlsx - Microsoft Excel
File
Home
Insert
Page Layout
Formulas
Data
Review
View
Developer
Team
SUM
=INDEX(E3:Q3,1,B4)
Swap
IndexSwap
Min
IndexMin
=INDE
1
1
10
1 2 3 4 5 6 7 8 9 10 11 12 13
13 5 3 10 14 4 8 11 7 1 9 6 12
X
We also the swap value, which we can find with INDEX
Step1 Step2 Step3 Step3a Step4 Step5 Step6 Step7 Step8 Step9
Edit
140%


SelectionSort.xlsx - Microsoft Excel
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Review
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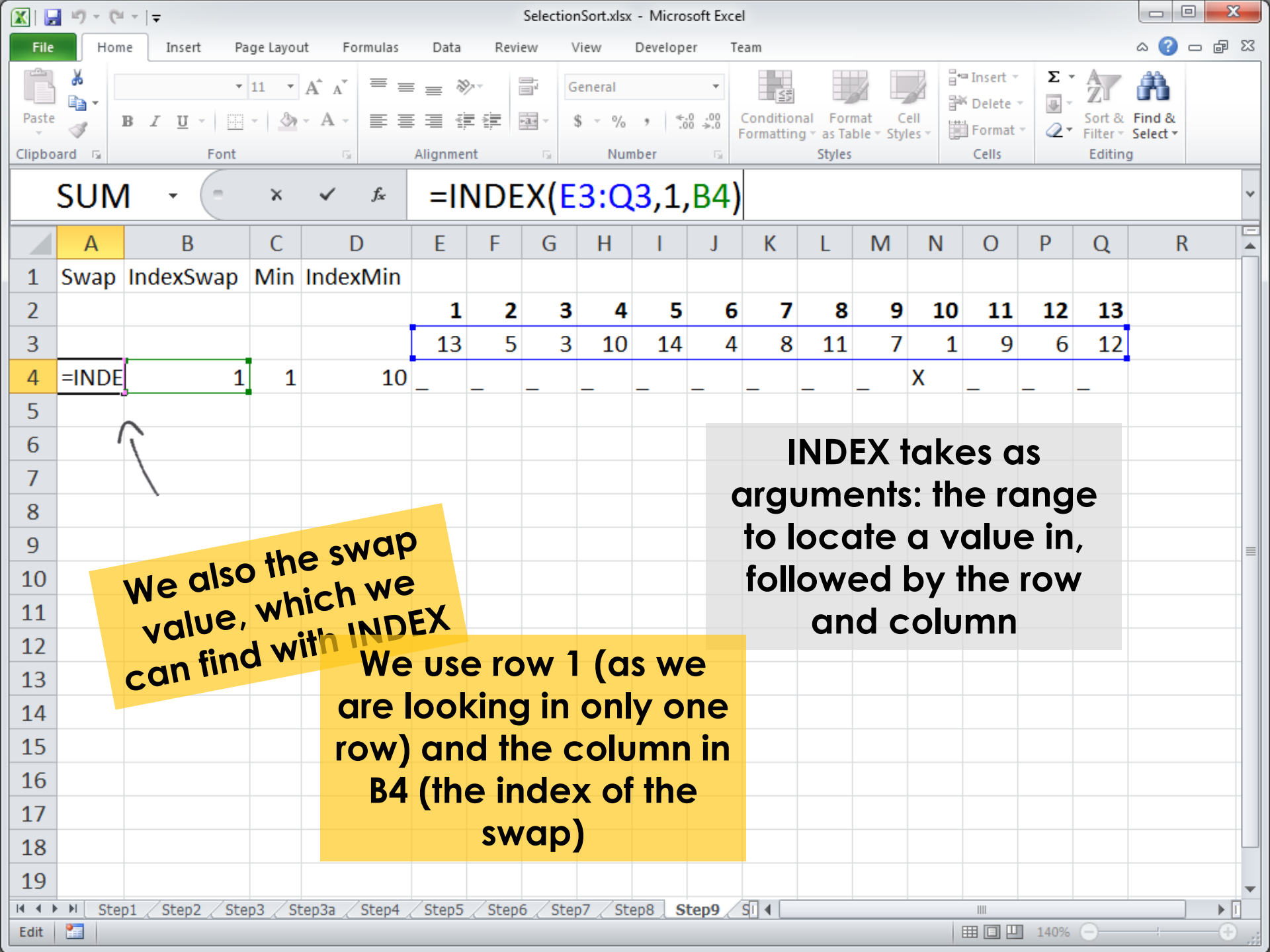
Developer
Team
SUM
=INDEX(E3:Q3,1,B4)
Swap
IndexSwap
Min
IndexMin
=INDE
1
1
10
1 2 3 4 5 6 7 8 9 10 11 12 13
13 5 3 10 14 4 8 11 7 1 9 6 12
X
We also the swap value, which we can find with INDEX
INDEX takes as arguments: the range to locate a value in, followed by the row and column
Step1 Step2 Step3 Step3a Step4 Step5 Step6 Step7 Step8 Step9
Edit
140%


SelectionSort.xlsx - Microsoft Excel
File
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Formulas
Data
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View
Developer
Team
SUM
=INDEX(E3:Q3,1,B4)
A B C D E F G H I J K L M N O P Q R
1 Swap IndexSwap Min IndexMin
2 1 2 3 4 5 6 7 8 9 10 11 12 13
3 13 5 3 10 14 4 8 11 7 1 9 6 12
4 =INDE 1 1 10 _ _ _ _ _ _ _ _ _ X _ _ _
INDEX takes as arguments: the range to locate a value in, followed by the row and column
We also the swap value, which we can find with INDEX
We use row 1 (as we are looking in only one row) and the column in B4 (the index of the swap)
Step1 Step2 Step3 Step3a Step4 Step5 Step6 Step7 Step8 Step9
Edit
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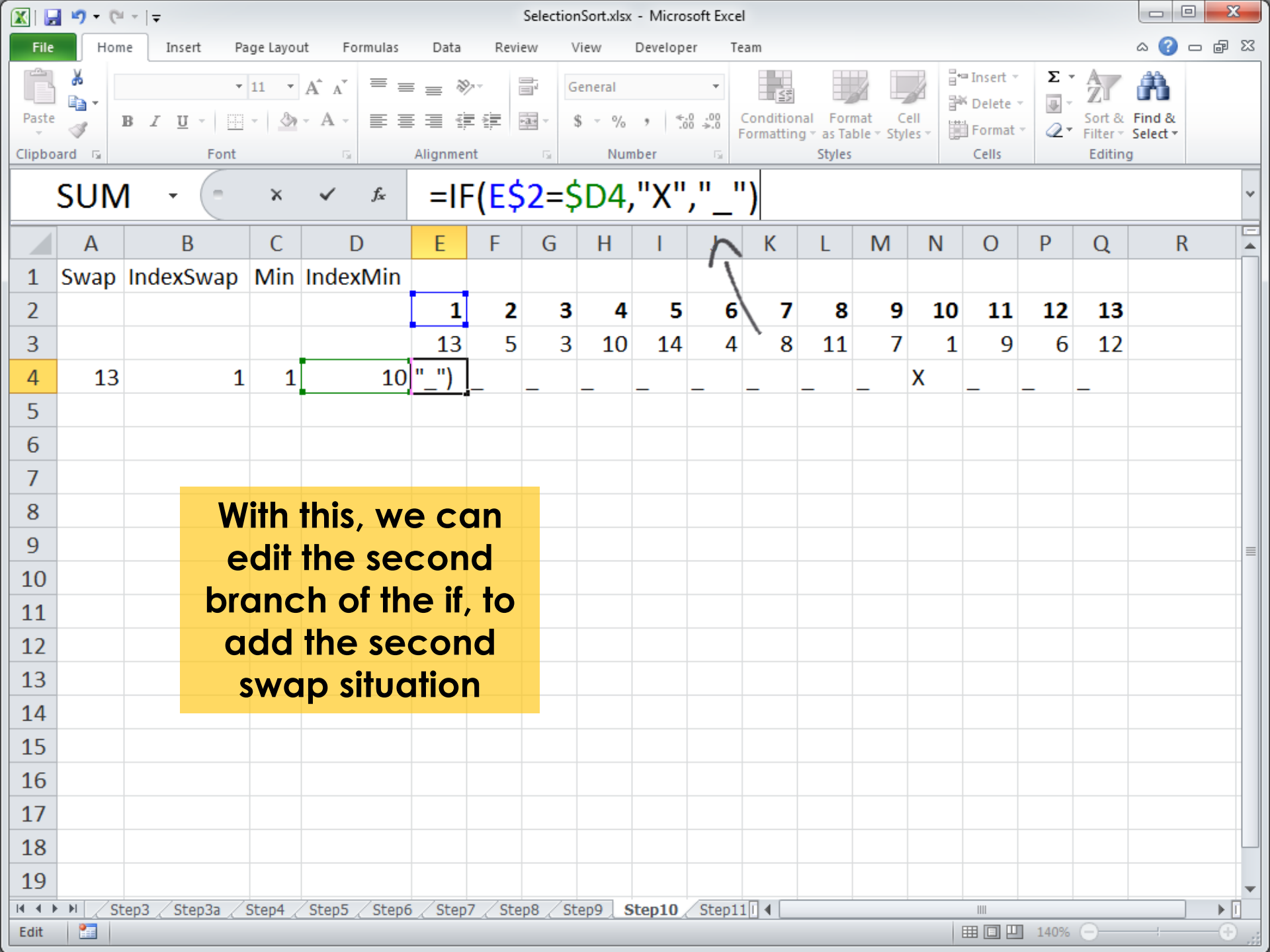
SelectionSort.xlsx - Microsoft Excel
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View
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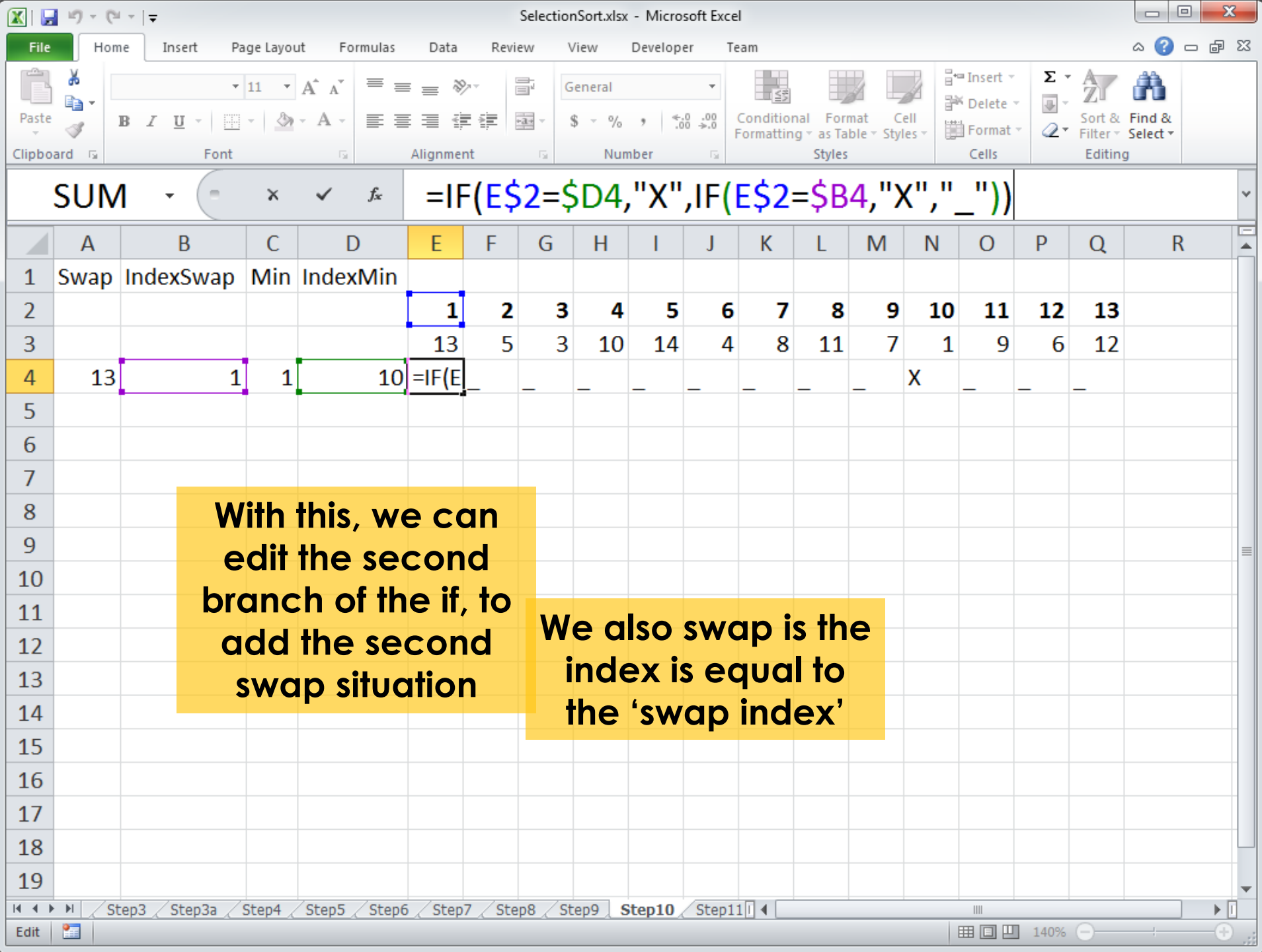
Team
SUM
=IF(E$2=$D4,"X","_")
Swap
IndexSwap
Min
IndexMin
1 2 3 4 5 6 7 8 9 10 11 12 13
13 5 3 10 14 4 8 11 7 1 9 6 12
13 1 1 10 "_") _ _ _ _ _ _ _ _ X _ _ _
With this, we can edit the second branch of the if, to add the second swap situation
Step3 Step3a Step4 Step5 Step6 Step7 Step8 Step9 Step10 Step11
Edit
140%


SelectionSort.xlsx - Microsoft Excel
File
Home
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Page Layout
Formulas
Data
Review
View
Developer
Team
SUM
=IF(E$2=$D4,"X",IF(E$2=$B4,"X","_"))
Swap
IndexSwap
Min
IndexMin
13
1
1
10
=IF(E
1 2 3 4 5 6 7 8 9 10 11 12 13
13 5 3 10 14 4 8 11 7 1 9 6 12
With this, we can edit the second branch of the if, to add the second swap situation
We also swap is the index is equal to the 'swap index'
Step3 Step3a Step4 Step5 Step6 Step7 Step8 Step9 Step10 Step11
Edit
140%

SelectionSort.xlsx - Microsoft Excel

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Paste | Calibri | 11 | Conditional Formatting | Format as Table | Cell Styles | Insert | Delete | Format | Sort & Filter | Find & Select

Clipboard | Font | Alignment | Number | Styles | Cells | Editing

E4 =IF(E$2=$D4,"X",IF(E$2=$B4,"X","_"))

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
1	Swap	IndexSwap	Min	IndexMin														
2					**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	
3					13	5	3	10	14	4	8	11	7	1	9	6	12	
4	13	1	1	10	X	_	_	_	_	_	_	_	_	X	_	_	_	
5																		
6																		
7																		
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18																		
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Works!
We marked both swap spots with an X

Step3 | Step3a | Step4 | Step5 | Step6 | Step7 | Step8 | Step9 | **Step10** | Step11

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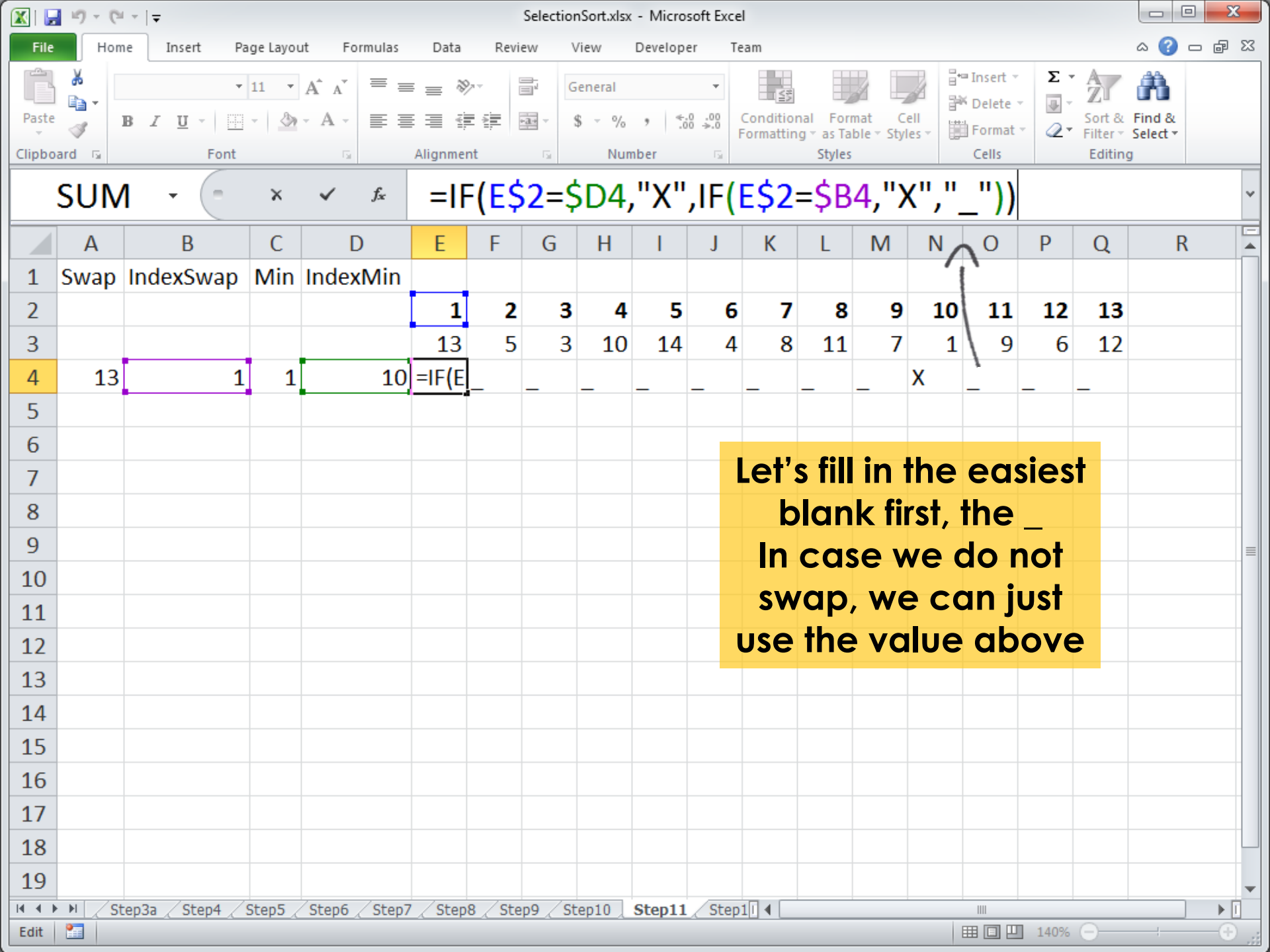
SelectionSort.xlsx - Microsoft Excel
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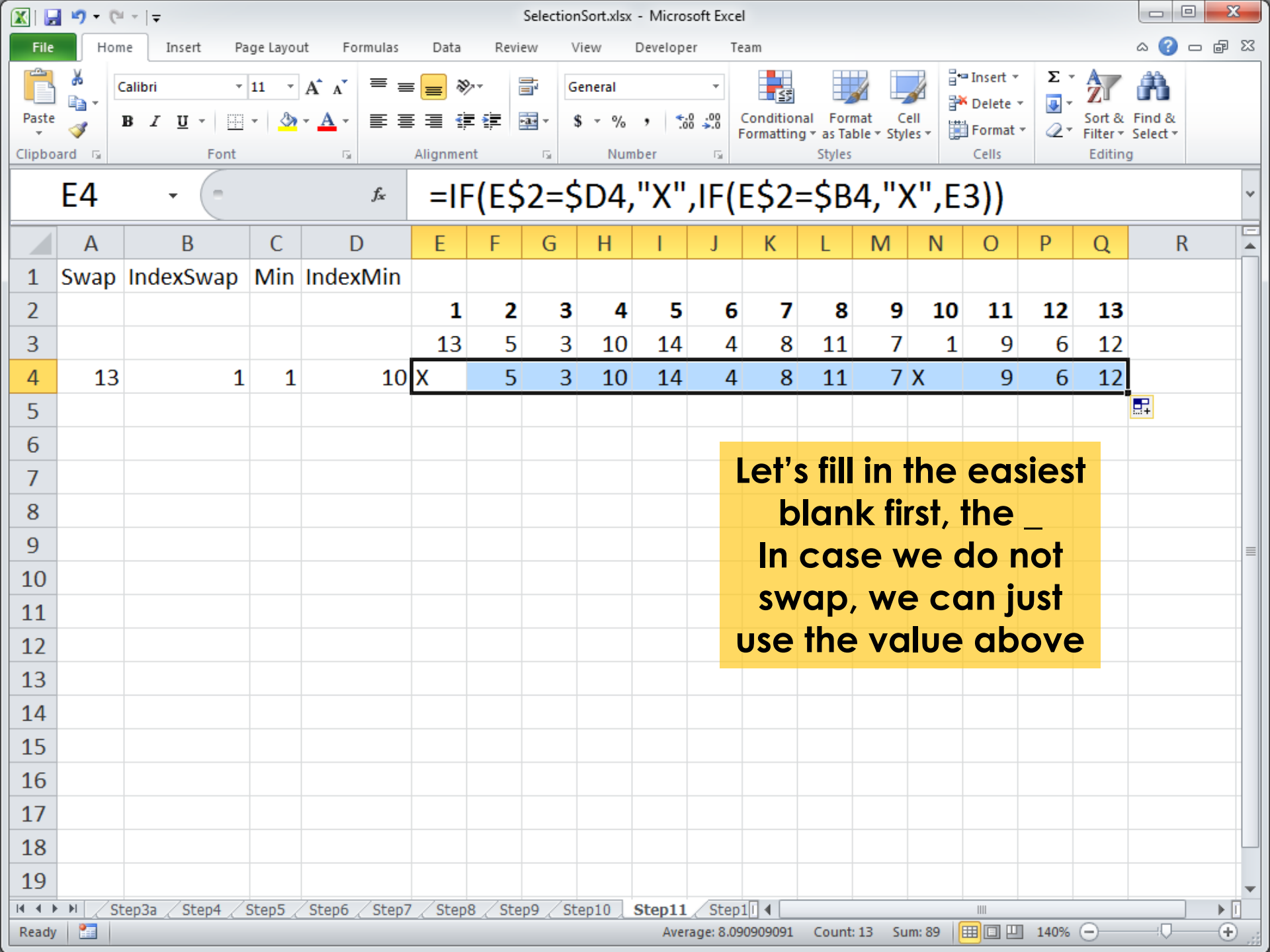
Team
SUM
=IF(E$2=$D4,"X",IF(E$2=$B4,"X","_"))
Swap
IndexSwap
Min
IndexMin
1 2 3 4 5 6 7 8 9 10 11 12 13
13 5 3 10 14 4 8 11 7 1 9 6 12
13 1 1 10 =IF(E
X
Let's fill in the easiest blank first, the _
In case we do not swap, we can just use the value above
Step3a Step4 Step5 Step6 Step7 Step8 Step9 Step10 Step11 Step1
Edit
140%



	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
1	Swap	IndexSwap	Min	IndexMin														
2					**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	
3					13	5	3	10	14	4	8	11	7	1	9	6	12	
4	13	1	1	10	X	5	3	10	14	4	8	11	7	X	9	6	12	
5																		
6																		
7																		
8																		
9																		
10																		
11																		
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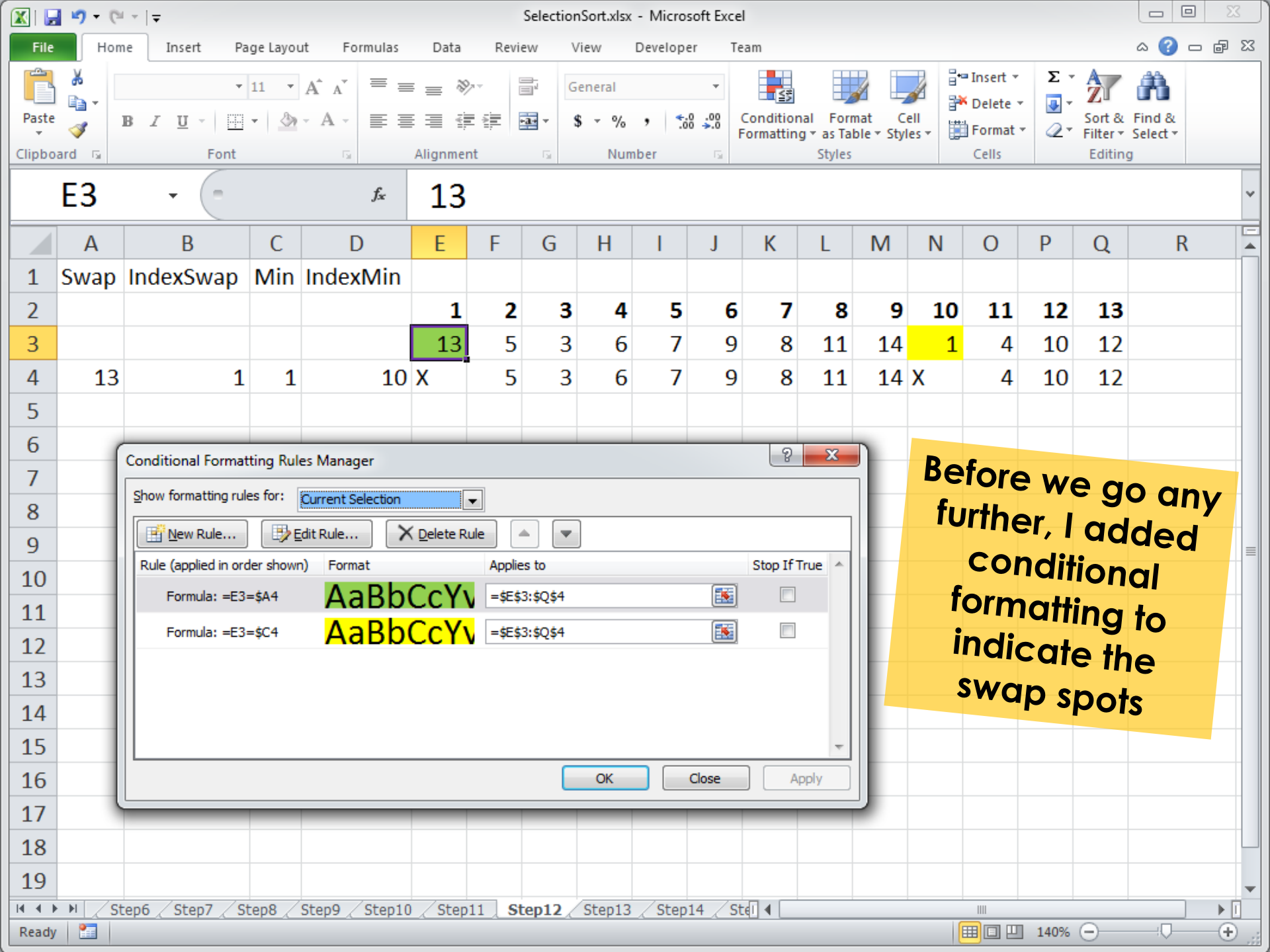
SelectionSort.xlsx - Microsoft Excel
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Cells
Sort & Filter
Find & Select
Editing
E3
13
Swap
IndexSwap
Min
IndexMin
1 2 3 4 5 6 7 8 9 10 11 12 13
13 5 3 6 7 9 8 11 14 1 4 10 12
13 1 1 10 X 5 3 6 7 9 8 11 14 X 4 10 12
Conditional Formatting Rules Manager
Show formatting rules for:
Current Selection
New Rule...
Edit Rule...
Delete Rule
Rule (applied in order shown)
Format
Applies to
Stop If True
Formula: =E3=$A4
AaBbCcYy
=$E$3:$Q$4
Formula: =E3=$C4
AaBbCcYy
=$E$3:$Q$4
OK
Close
Apply
Before we go any further, I added conditional formatting to indicate the swap spots
Step6
Step7
Step8
Step9
Step10
Step11
Step12
Step13
Step14
Ready
140%

SelectionSort.xlsx - Microsoft Excel

File | Home | Insert | Page Layout | Formulas | Data | Review | View | Developer | Team

=IF(E$2=$D4,"X",IF(E$2=$B4,"X",E3))

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
1	Swap	IndexSwap	Min	IndexMin														
2					1	2	3	4	5	6	7	8	9	10	11	12	13	
3					13	5	3	6	7	9	8	11	14	1	4	10	12	
4	13	1	1	10	=IF(E	5	3	6	7	9	8	11	14	X	4	10	12	
5																		
6																		
7																		
8																		
9																		
10																		
11																		
12																		
13																		
14																		
15																		
16																		
17																		
18																		
19																		

So what goes on this spot? If the index is equal to the swap spot...

Step6 | Step7 | Step8 | Step9 | Step10 | Step11 | Step12 | **Step13** | Step14 | Ste

Edit | 140%

SelectionSort.xlsx - Microsoft Excel

File | Home | Insert | Page Layout | Formulas | Data | Review | View | Developer | Team

SUM

=IF(E$2=$D4,"X",IF(E$2=$B4,$C4,E3))

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
1	Swap	IndexSwap	Min	IndexMin														
2					1	2	3	4	5	6	7	8	9	10	11	12	13	
3					13	5	3	6	7	9	8	11	14	1	4	10	12	
4	13	1	1	10	=IF(E	5	3	6	7	9	8	11	14	X	4	10	12	
5																		
6																		
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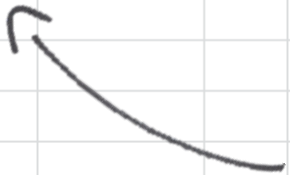

So what goes on this spot? If the index is equal to the swap spot, we output the minimum

Step6 | Step7 | Step8 | Step9 | Step10 | Step11 | Step12 | Step13 | Step14

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SelectionSort.xlsx - Microsoft Excel

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=IF(E$2=$D4,$A4,IF(E$2=$B4,$C4,E3))

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
1	Swap	IndexSwap	Min	IndexMin														
2					1	2	3	4	5	6	7	8	9	10	11	12	13	
3					13	5	3	6	7	9	8	11	14	1	4	10	12	
4	13	1	1	10	=IF(E	5	3	6	7	9	8	11	14	X	4	10	12	

And if the index is swap, we output the swap value

Step6 | Step7 | Step8 | Step9 | Step10 | Step11 | Step12 | Step13 | Step14

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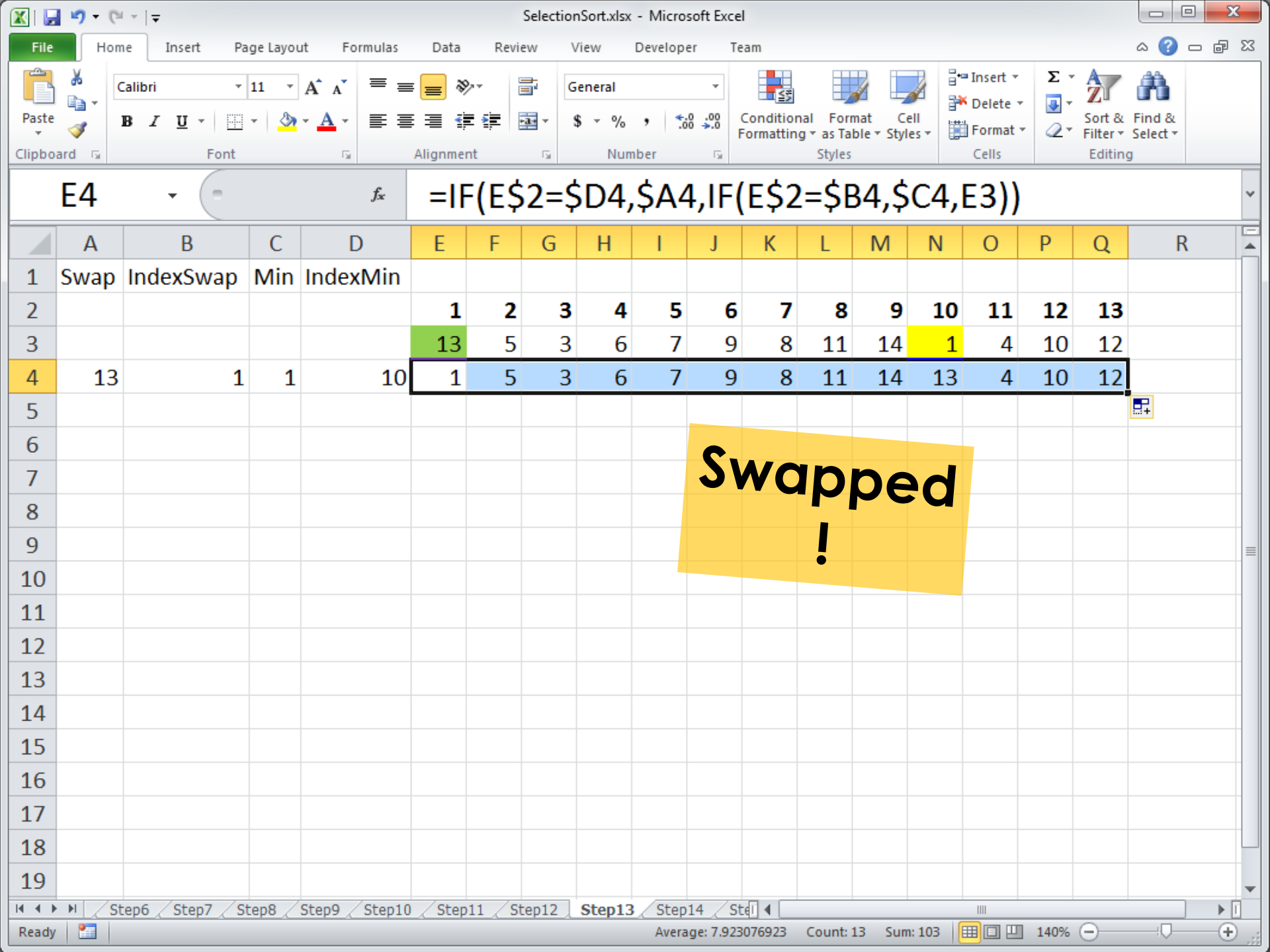

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
1	Swap	IndexSwap	Min	IndexMin														
2					**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	
3					13	5	3	6	7	9	8	11	14	1	4	10	12	
4	13	1	1	10	1	5	3	6	7	9	8	11	14	13	4	10	12	
5																		
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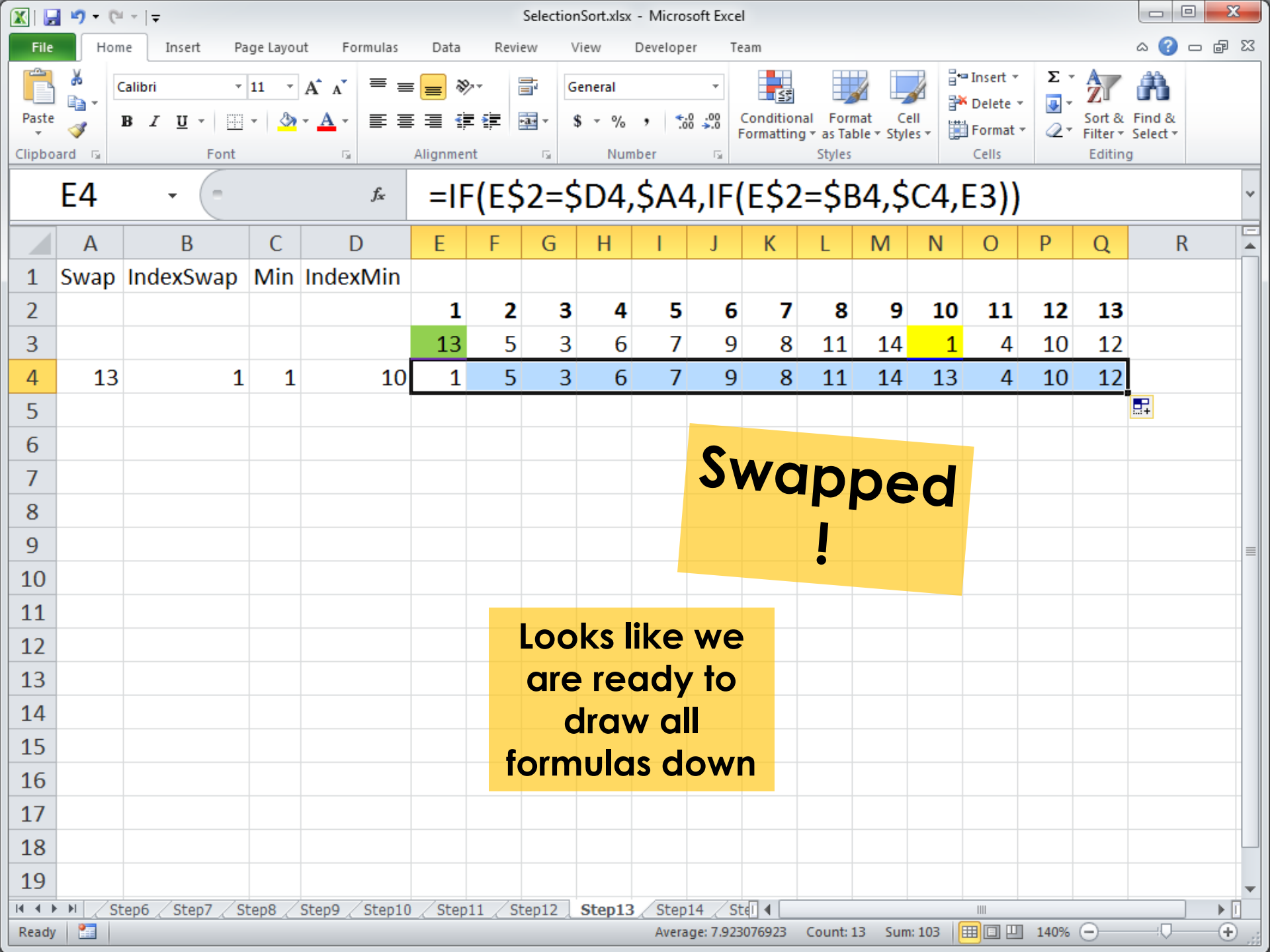

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
1	Swap	IndexSwap	Min	IndexMin														
2					**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	
3					13	5	3	6	7	9	8	11	14	1	4	10	12	
4	13	1	1	10	1	5	3	6	7	9	8	11	14	13	4	10	12	
5																		
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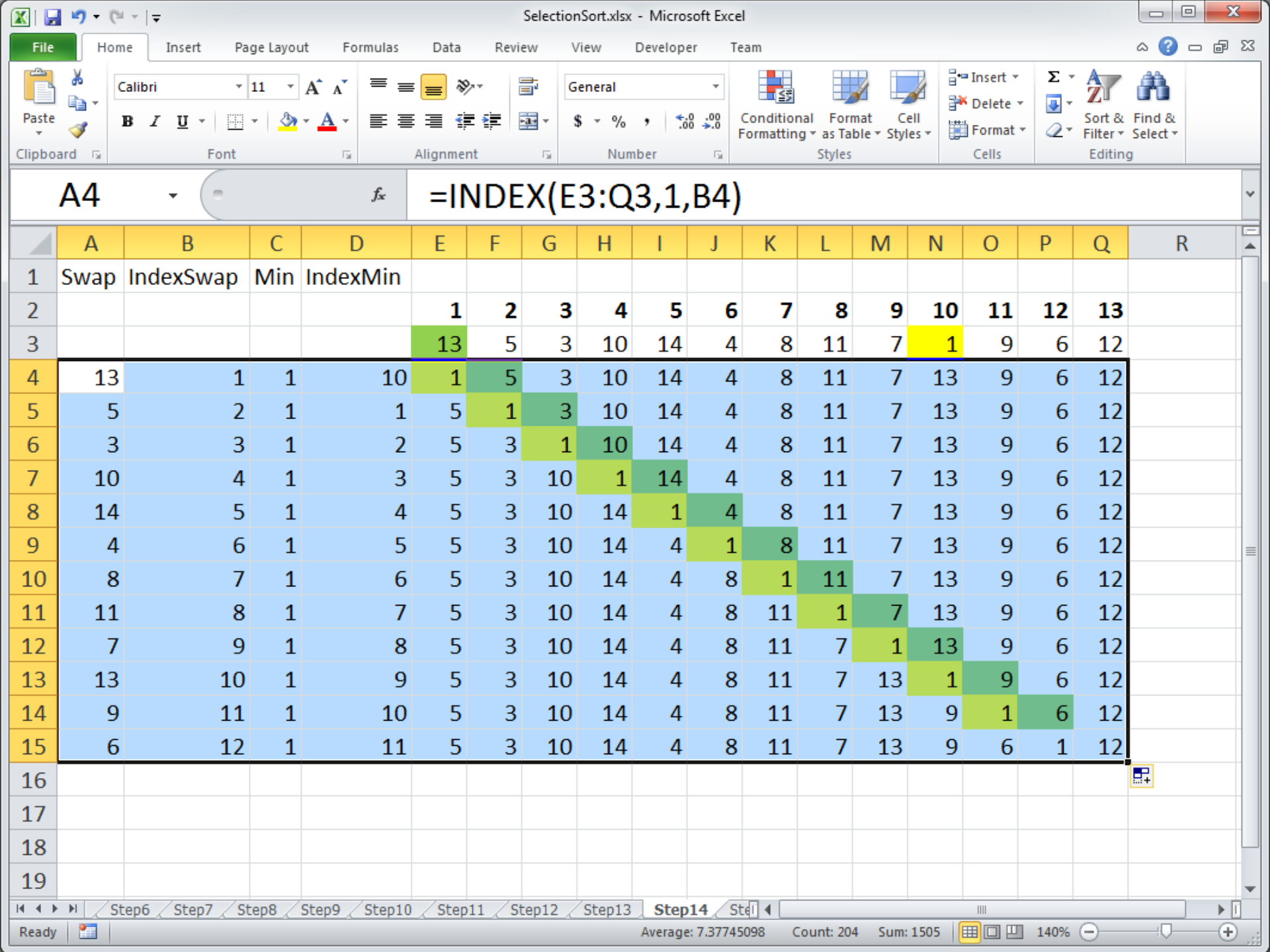

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
1	Swap	IndexSwap	Min	IndexMin														
2					**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	
3					13	5	3	10	14	4	8	11	7	1	9	6	12	
4	13	1	1	10	1	5	3	10	14	4	8	11	7	13	9	6	12	
5	5	2	1	1	5	1	3	10	14	4	8	11	7	13	9	6	12	
6	3	3	1	2	5	3	1	10	14	4	8	11	7	13	9	6	12	
7	10	4	1	3	5	3	10	1	14	4	8	11	7	13	9	6	12	
8	14	5	1	4	5	3	10	14	1	4	8	11	7	13	9	6	12	
9	4	6	1	5	5	3	10	14	4	1	8	11	7	13	9	6	12	
10	8	7	1	6	5	3	10	14	4	8	1	11	7	13	9	6	12	
11	11	8	1	7	5	3	10	14	4	8	11	1	7	13	9	6	12	
12	7	9	1	8	5	3	10	14	4	8	11	7	1	13	9	6	12	
13	13	10	1	9	5	3	10	14	4	8	11	7	13	1	9	6	12	
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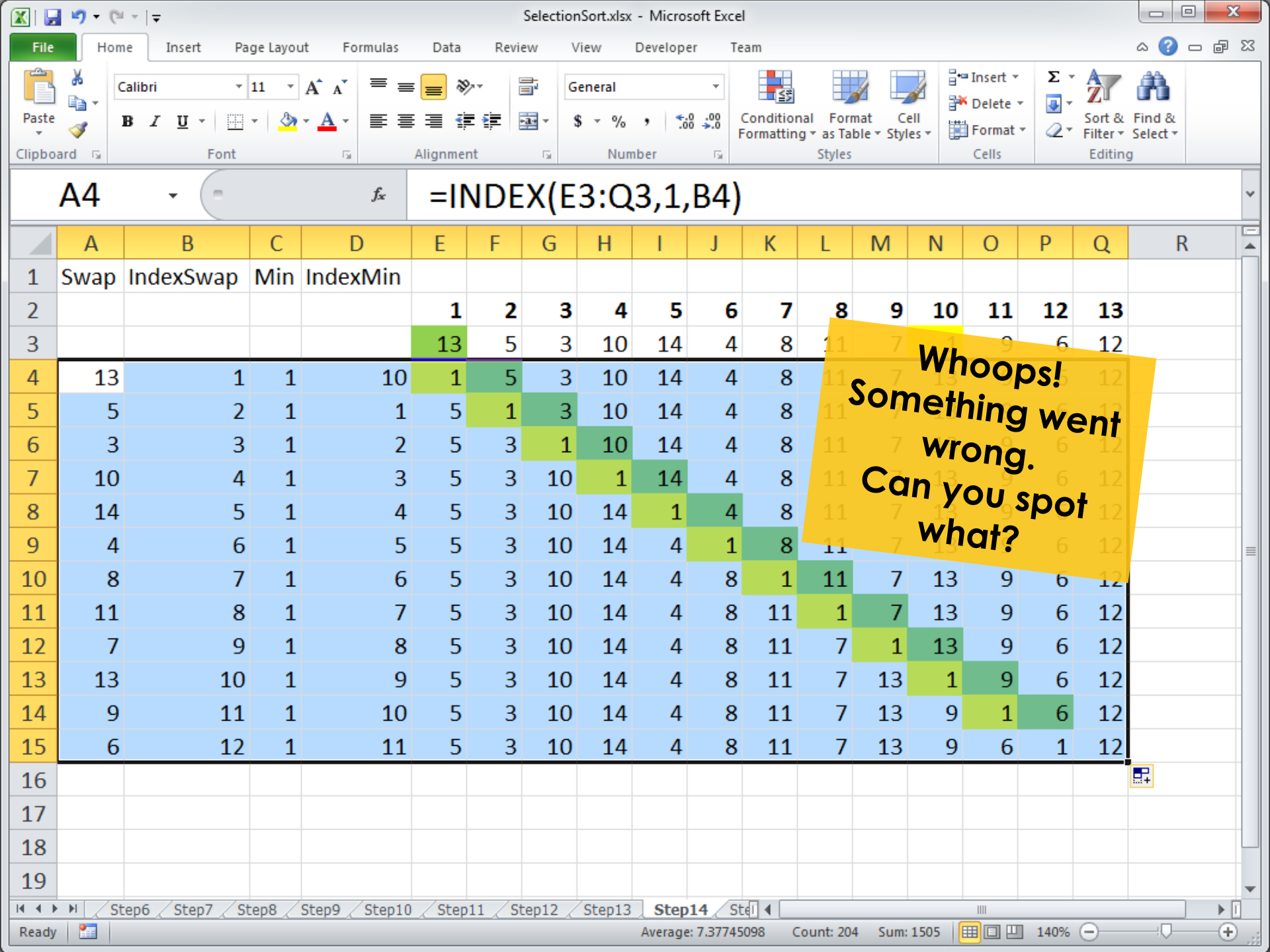

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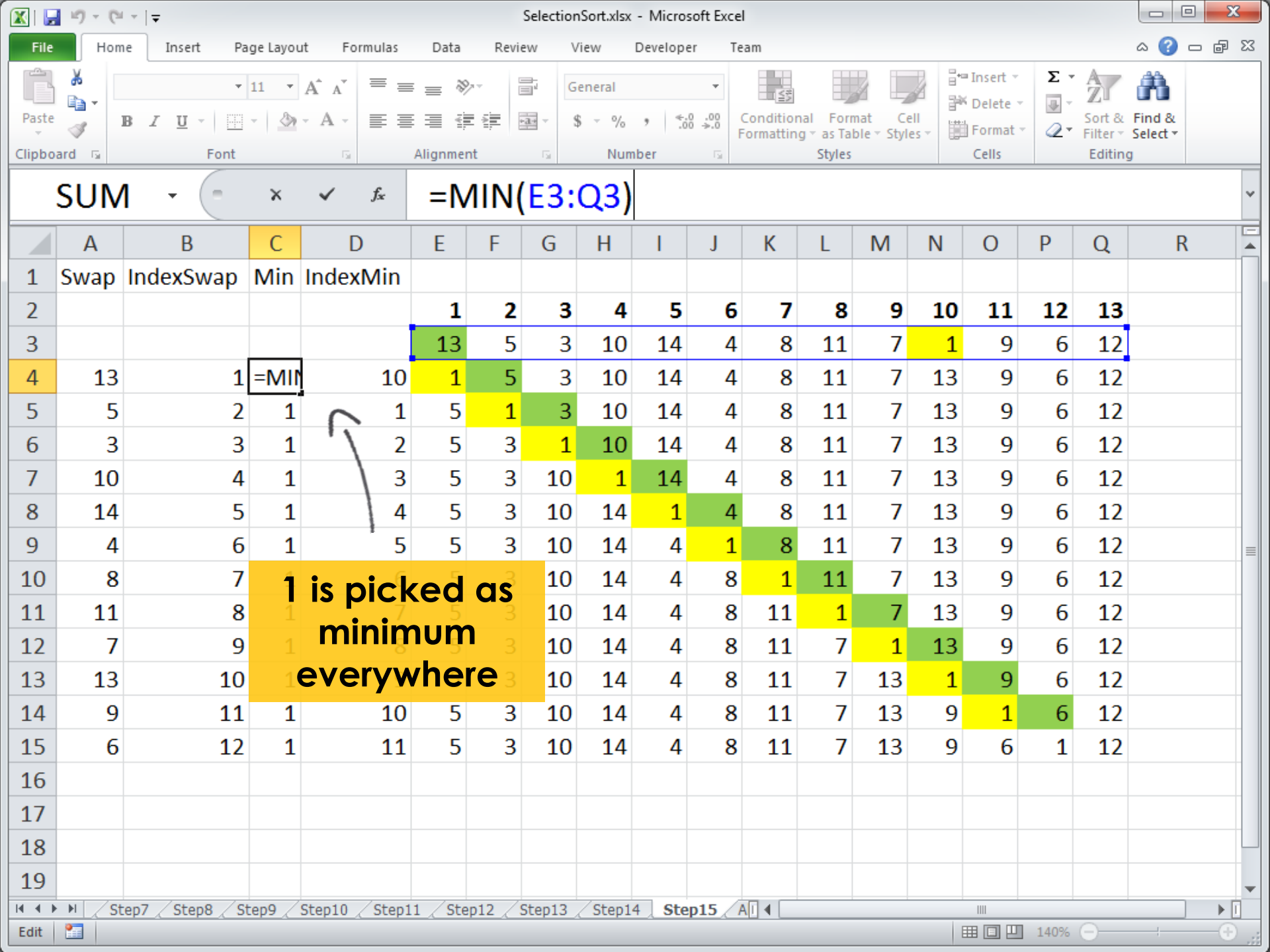

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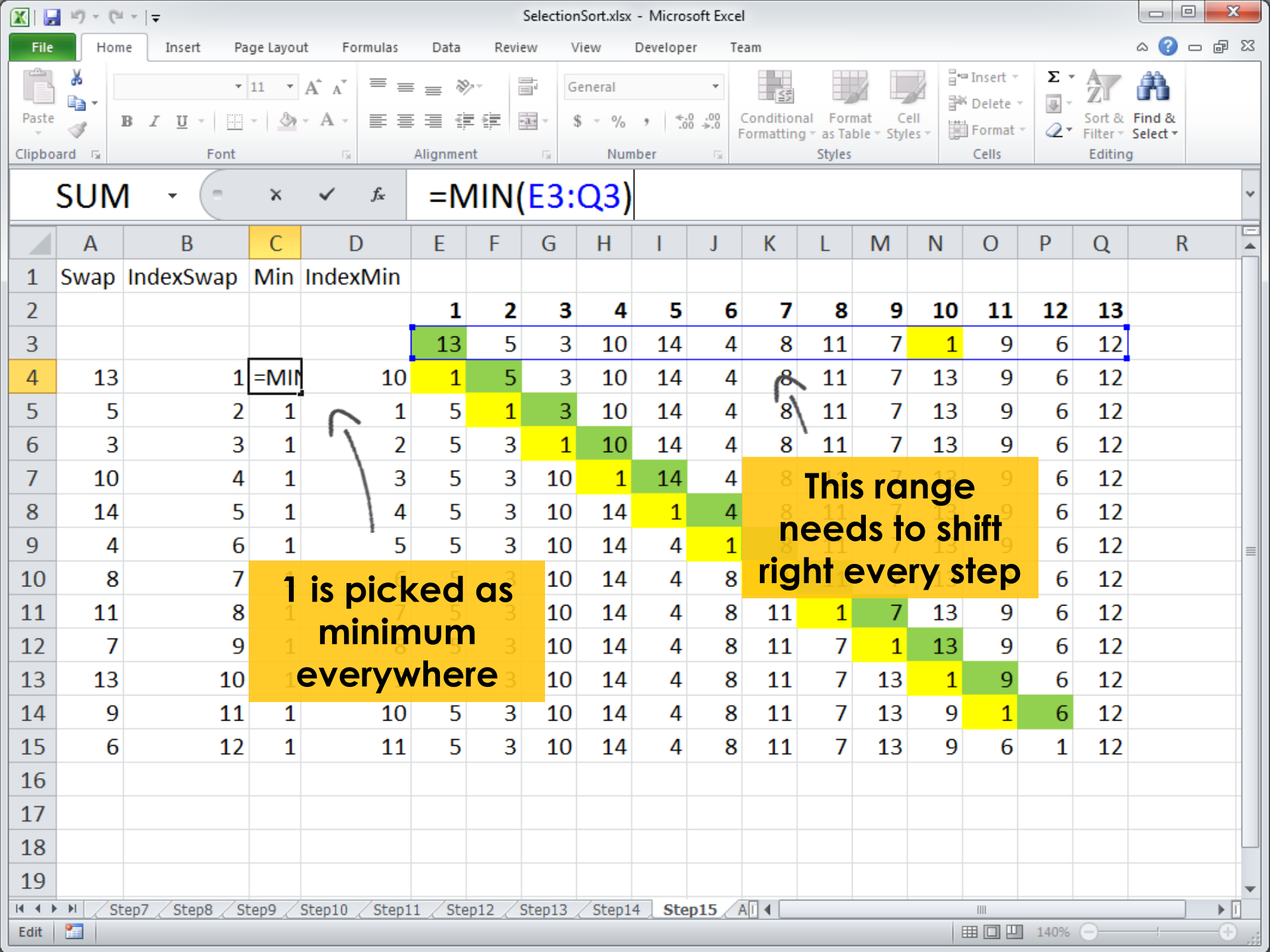

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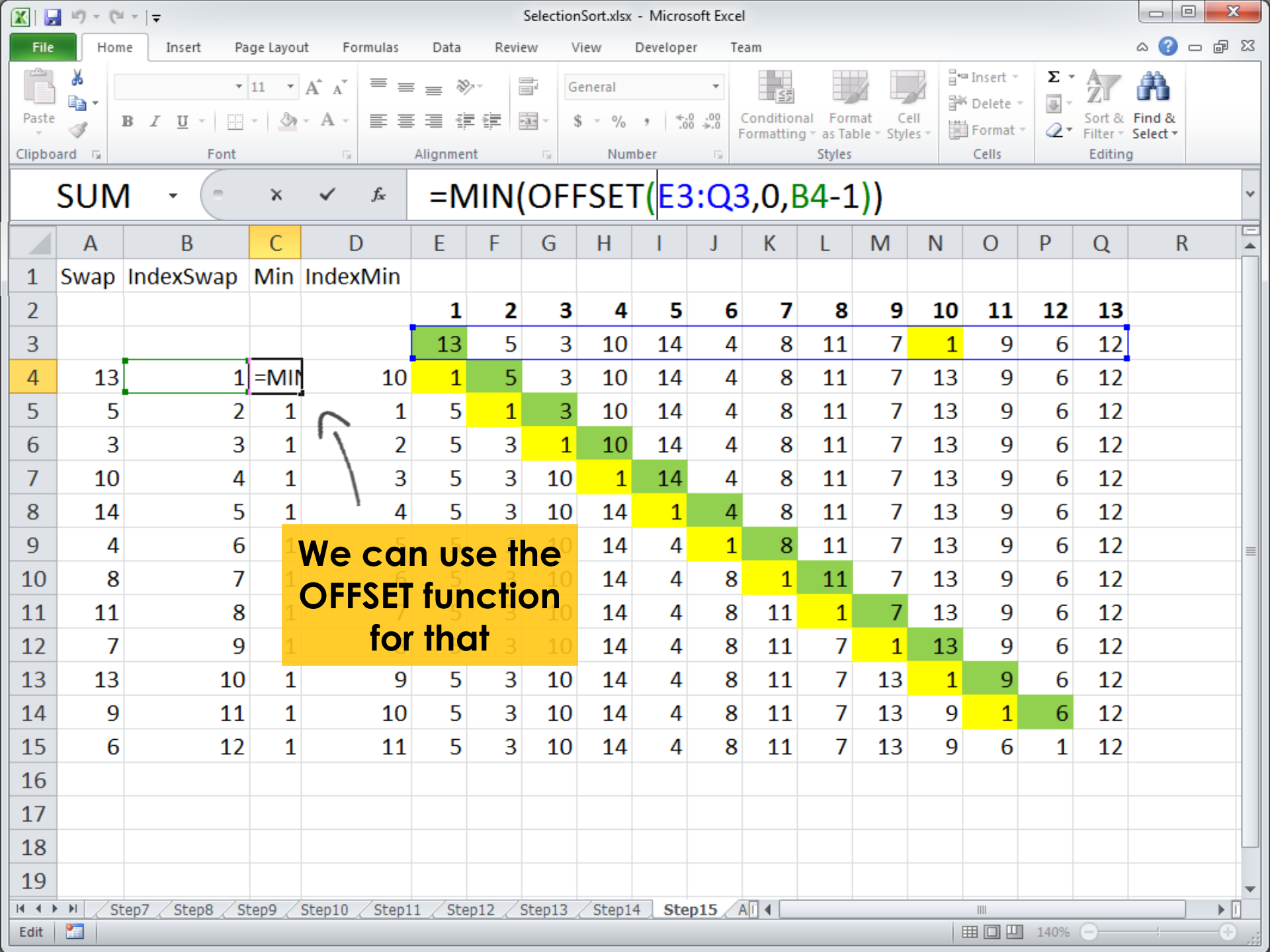
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Swap
IndexSwap
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IndexMin
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We can use the OFFSET function for that
Step7 Step8 Step9 Step10 Step11 Step12 Step13 Step14 Step15
Edit
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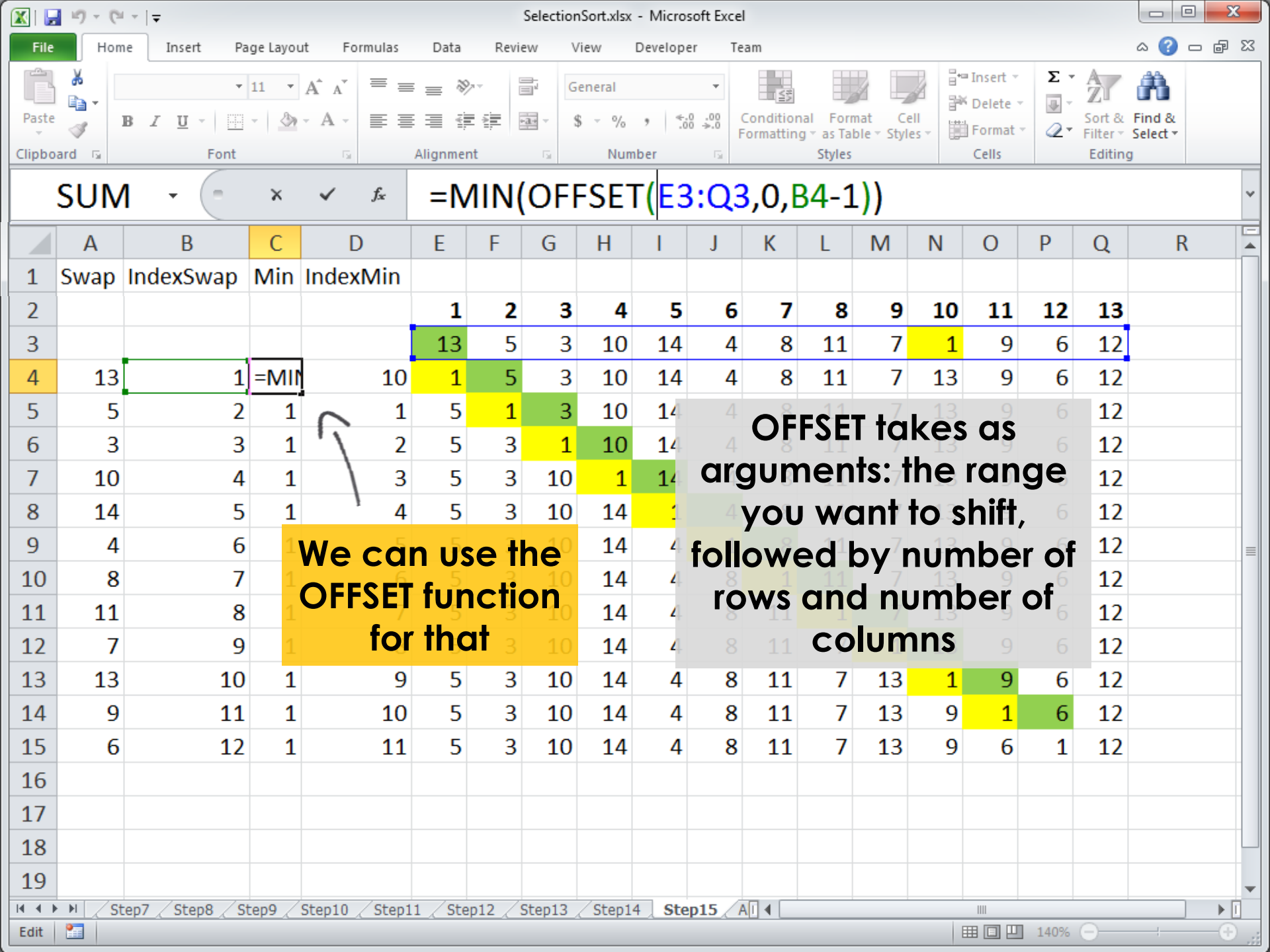

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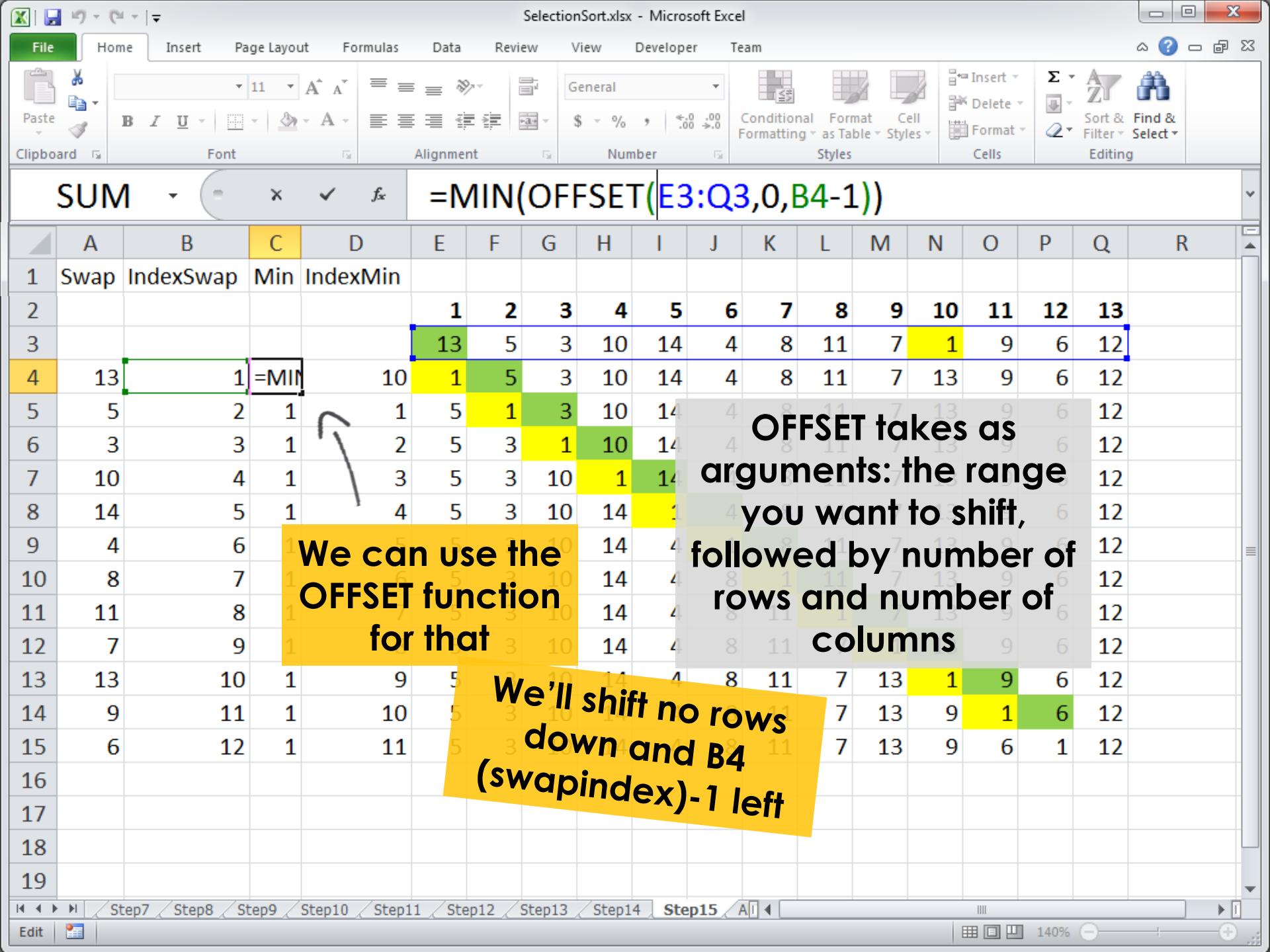

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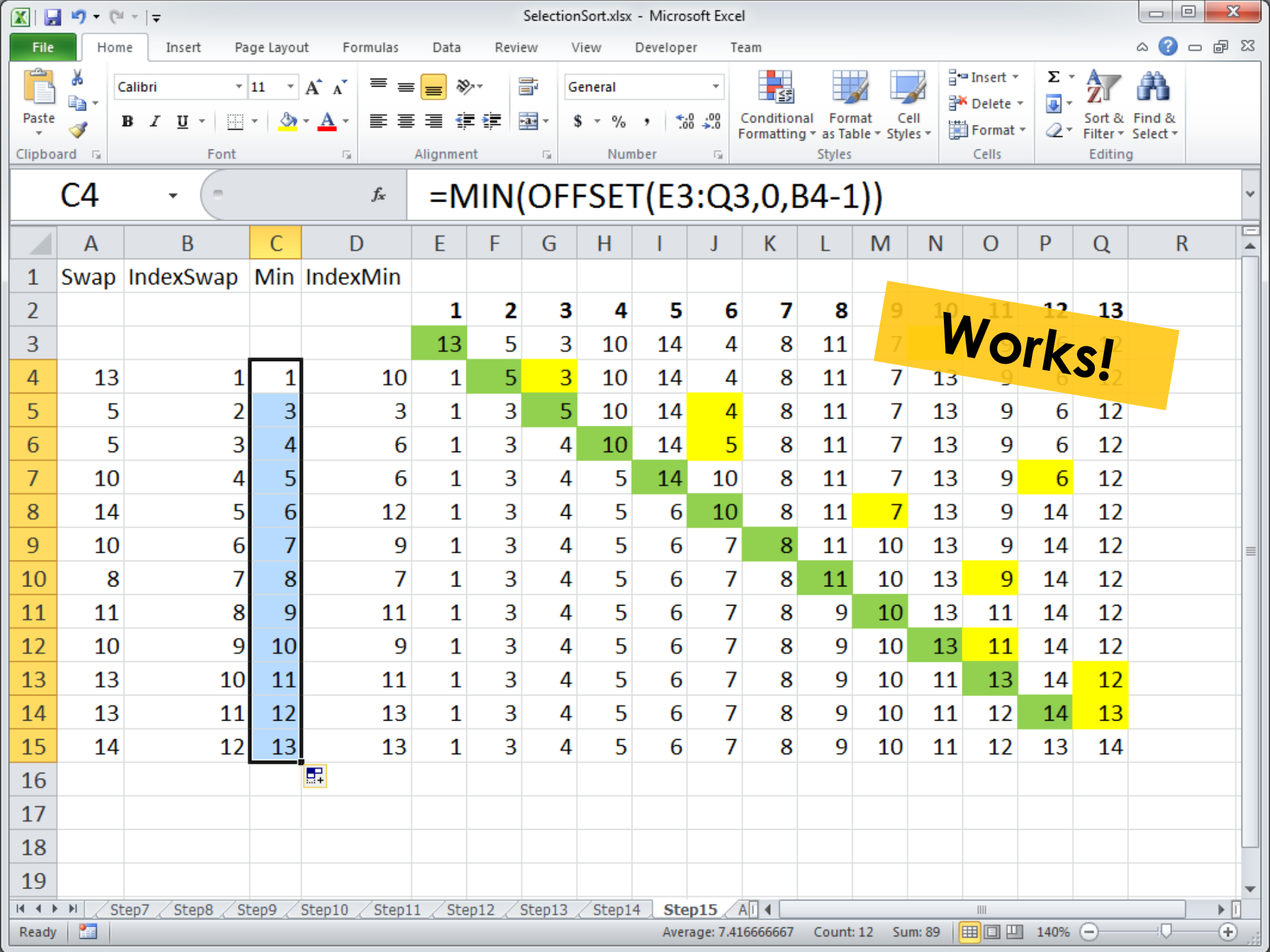

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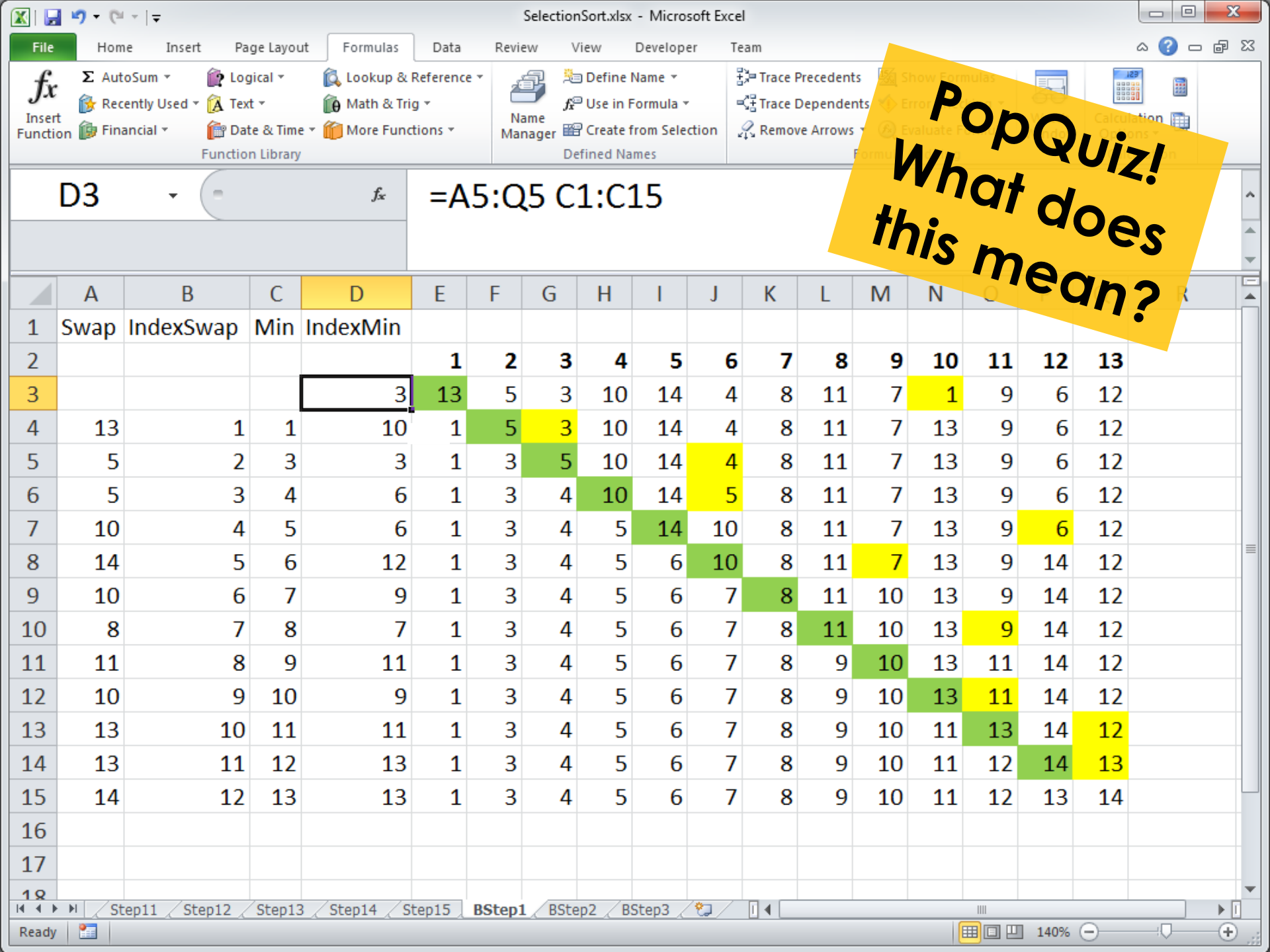
But let's make
things a bit scarier



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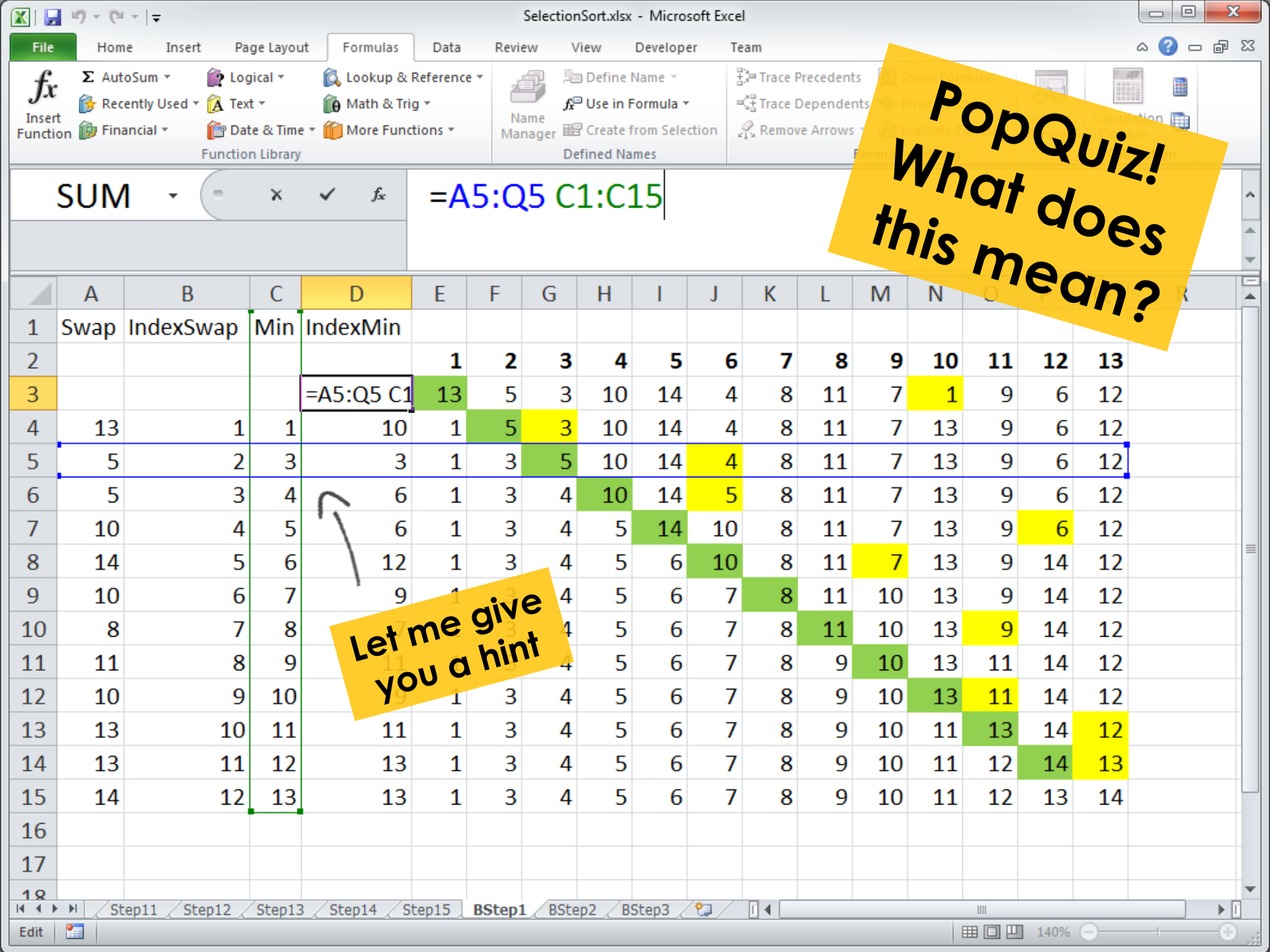

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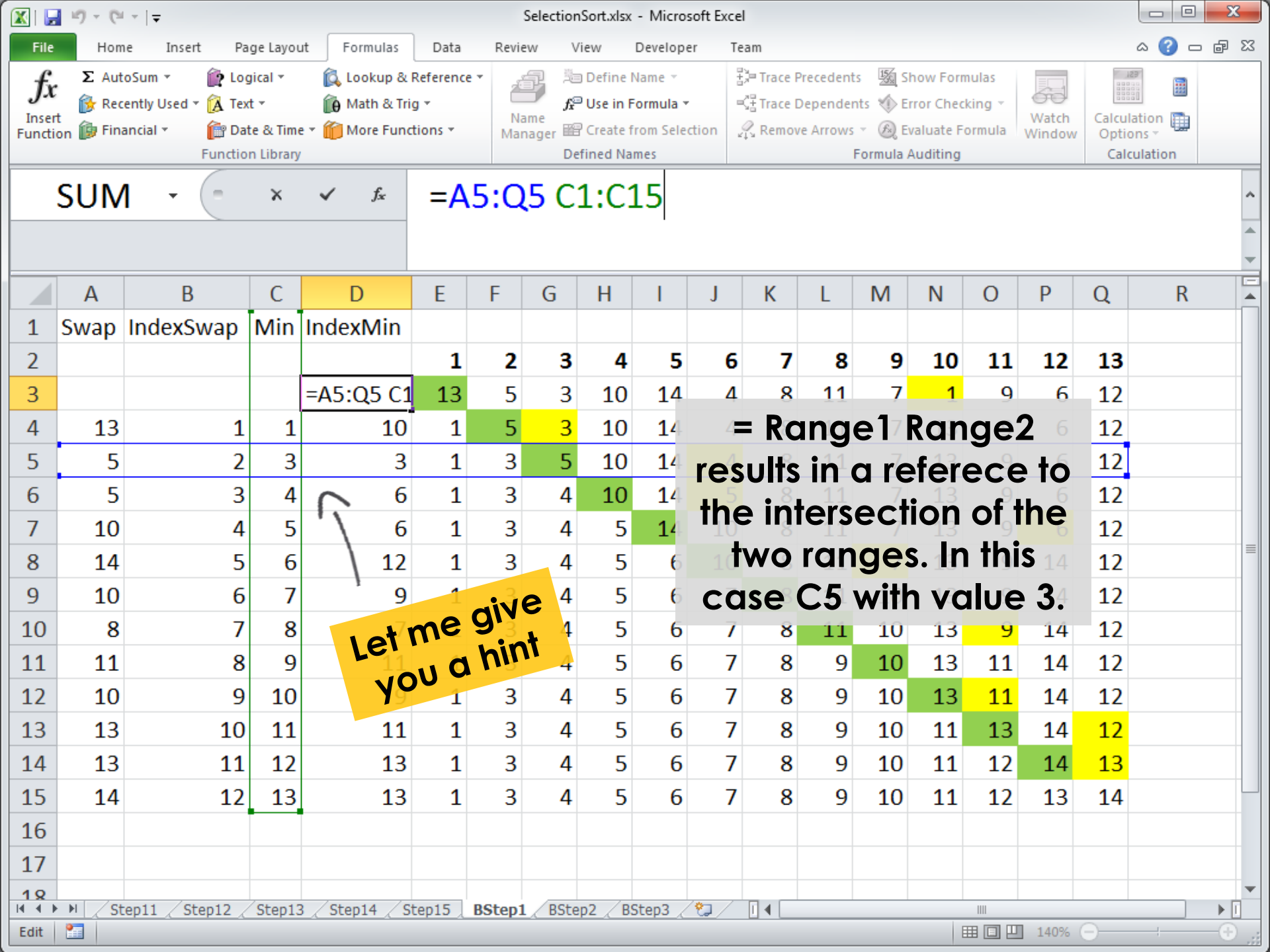

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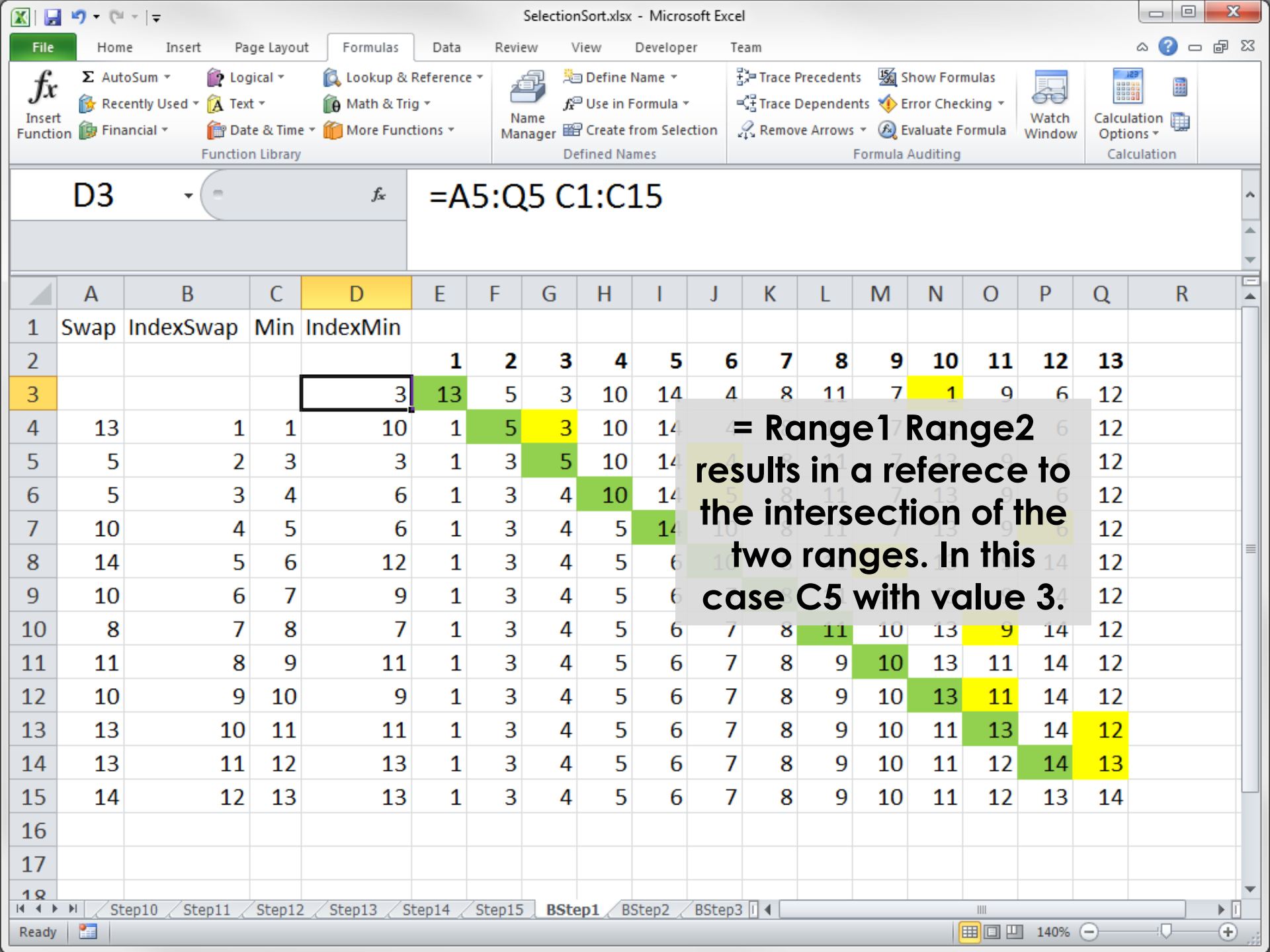

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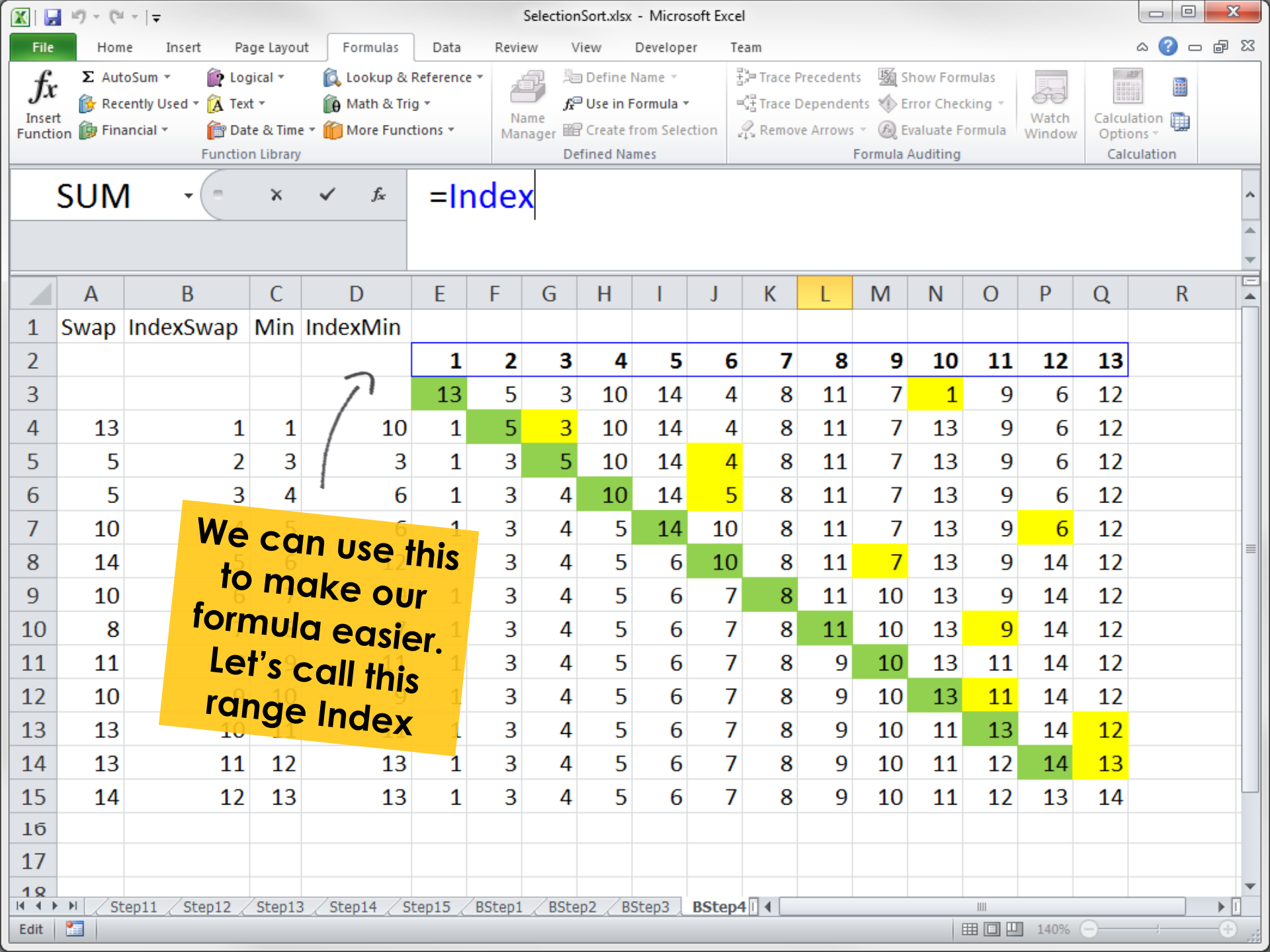

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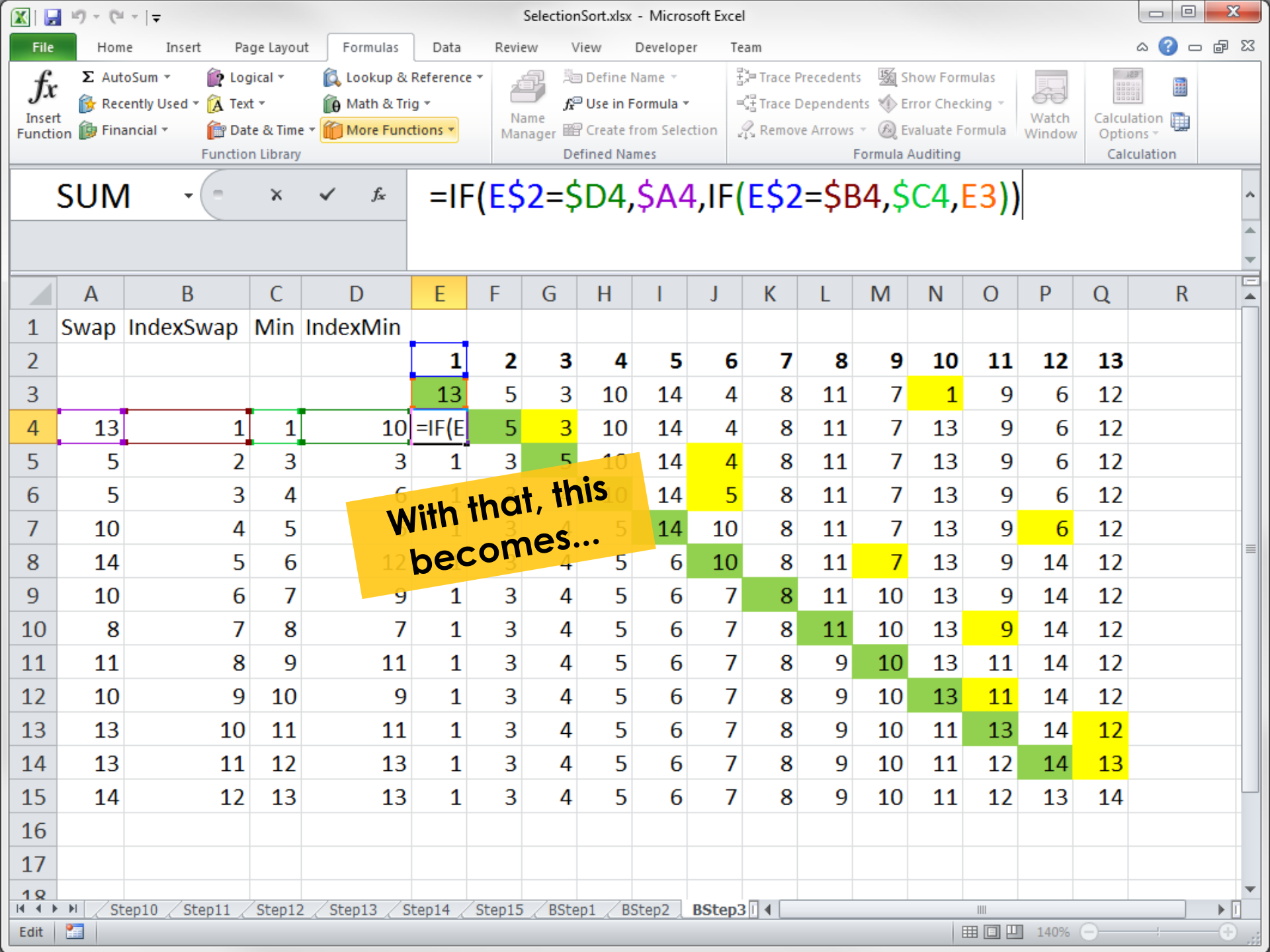

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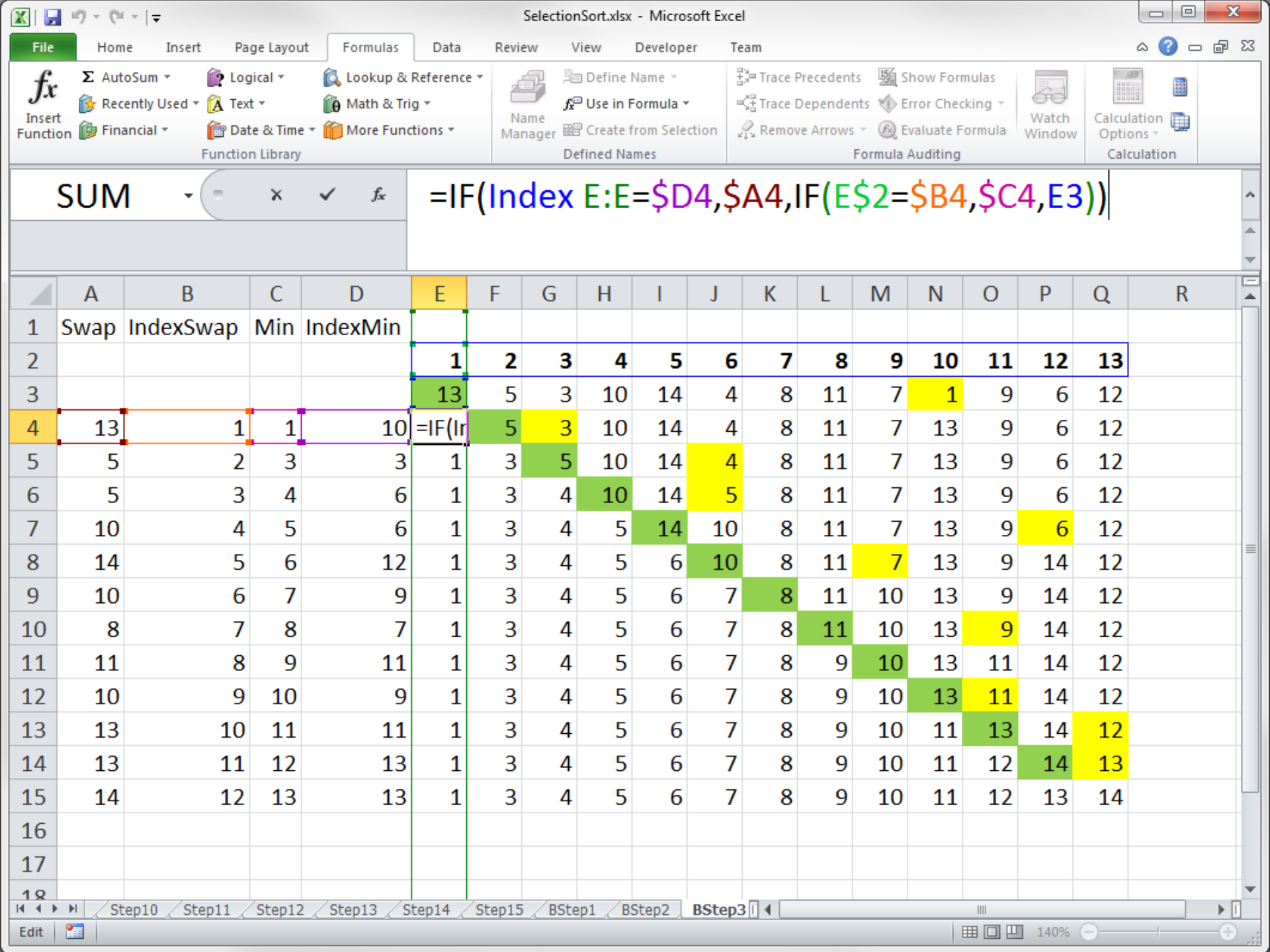

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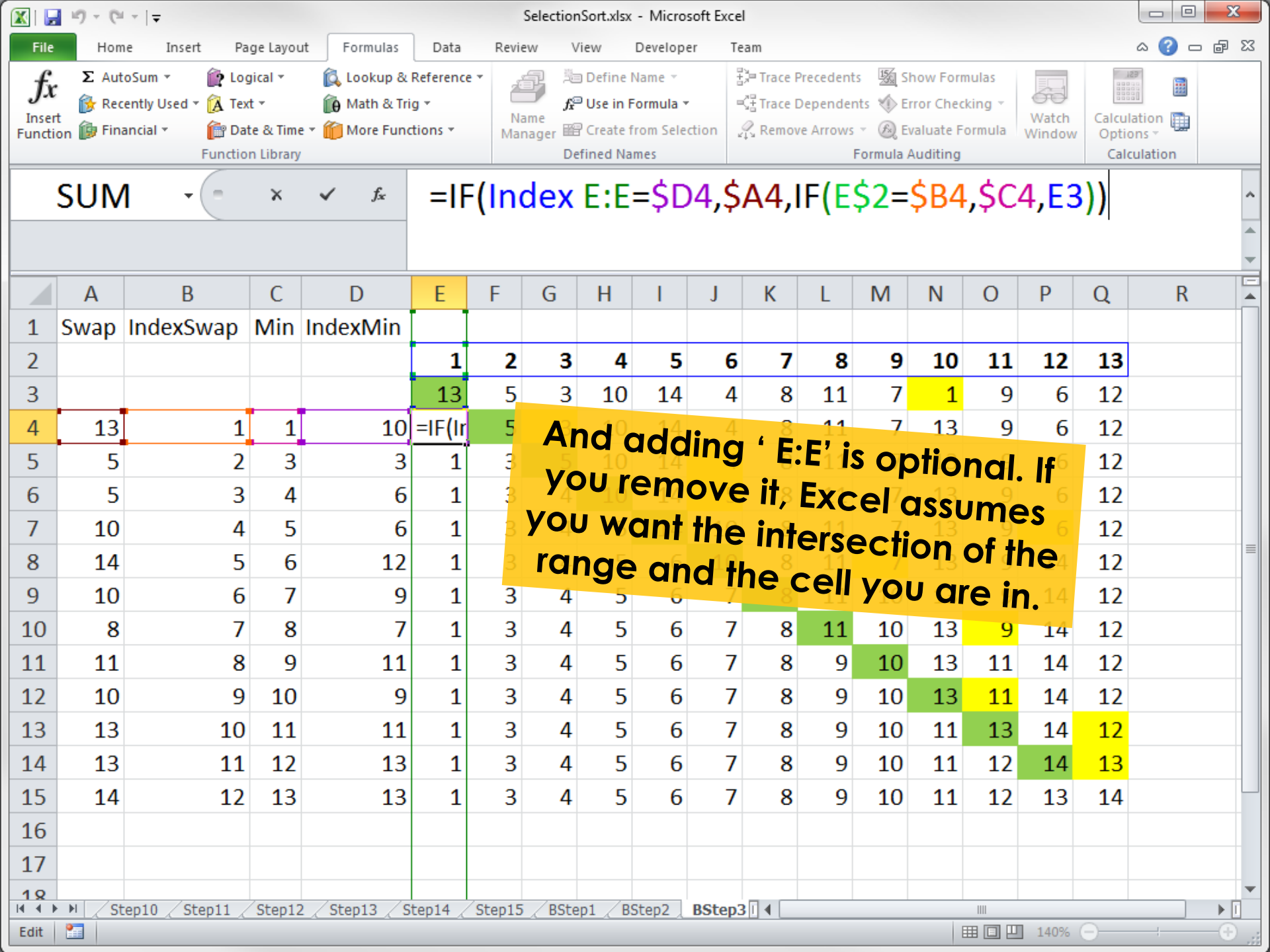

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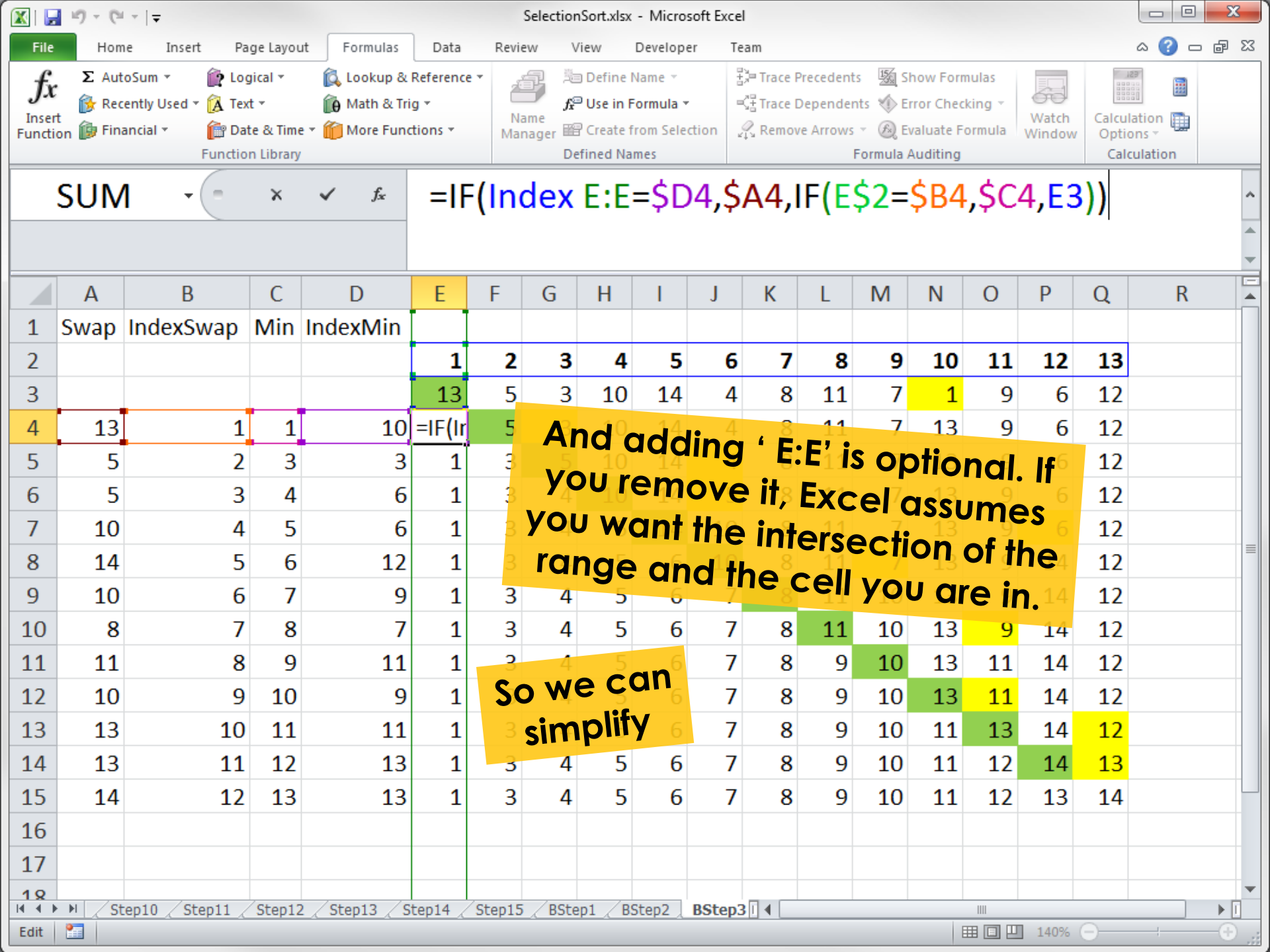

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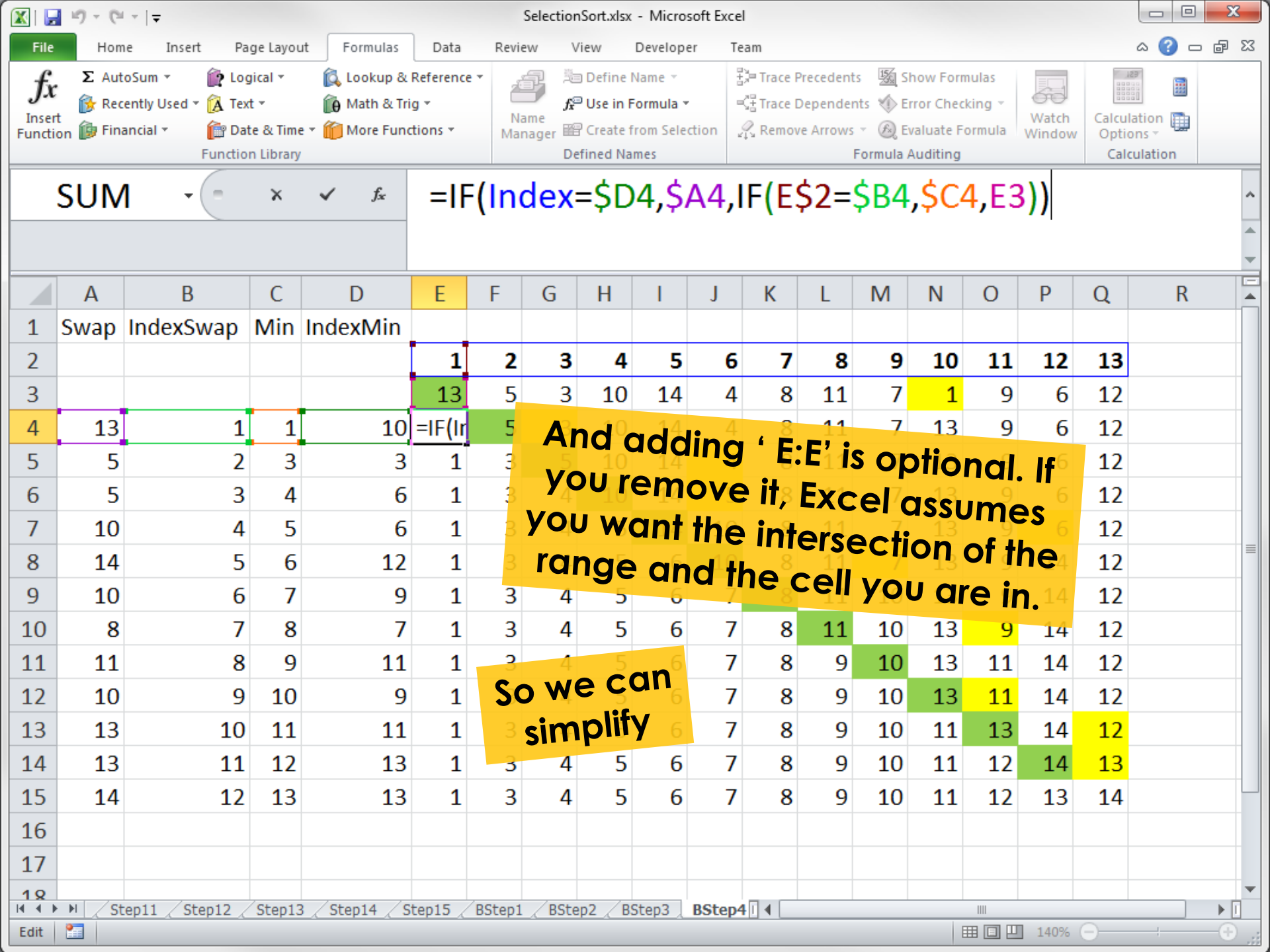

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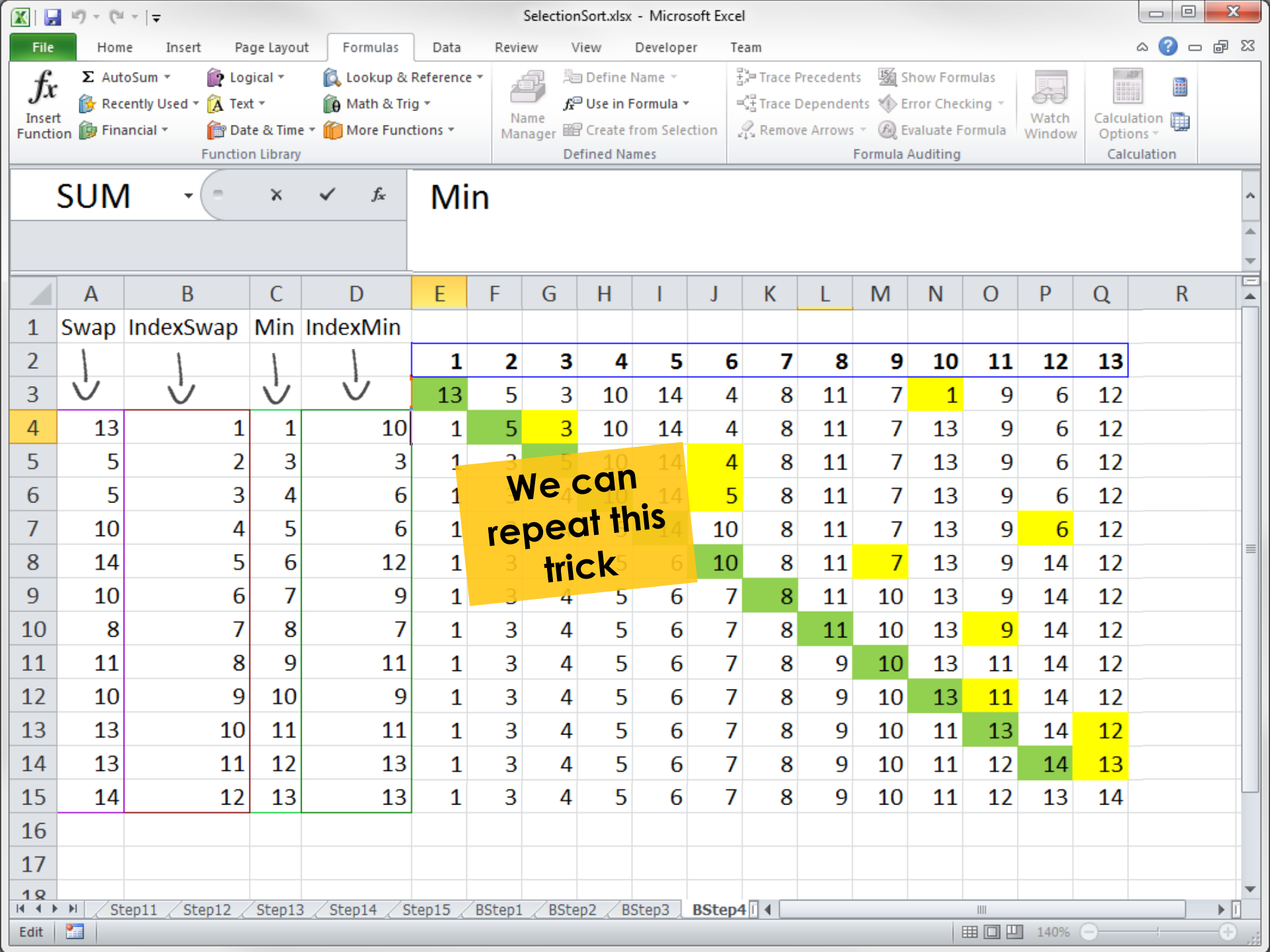

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
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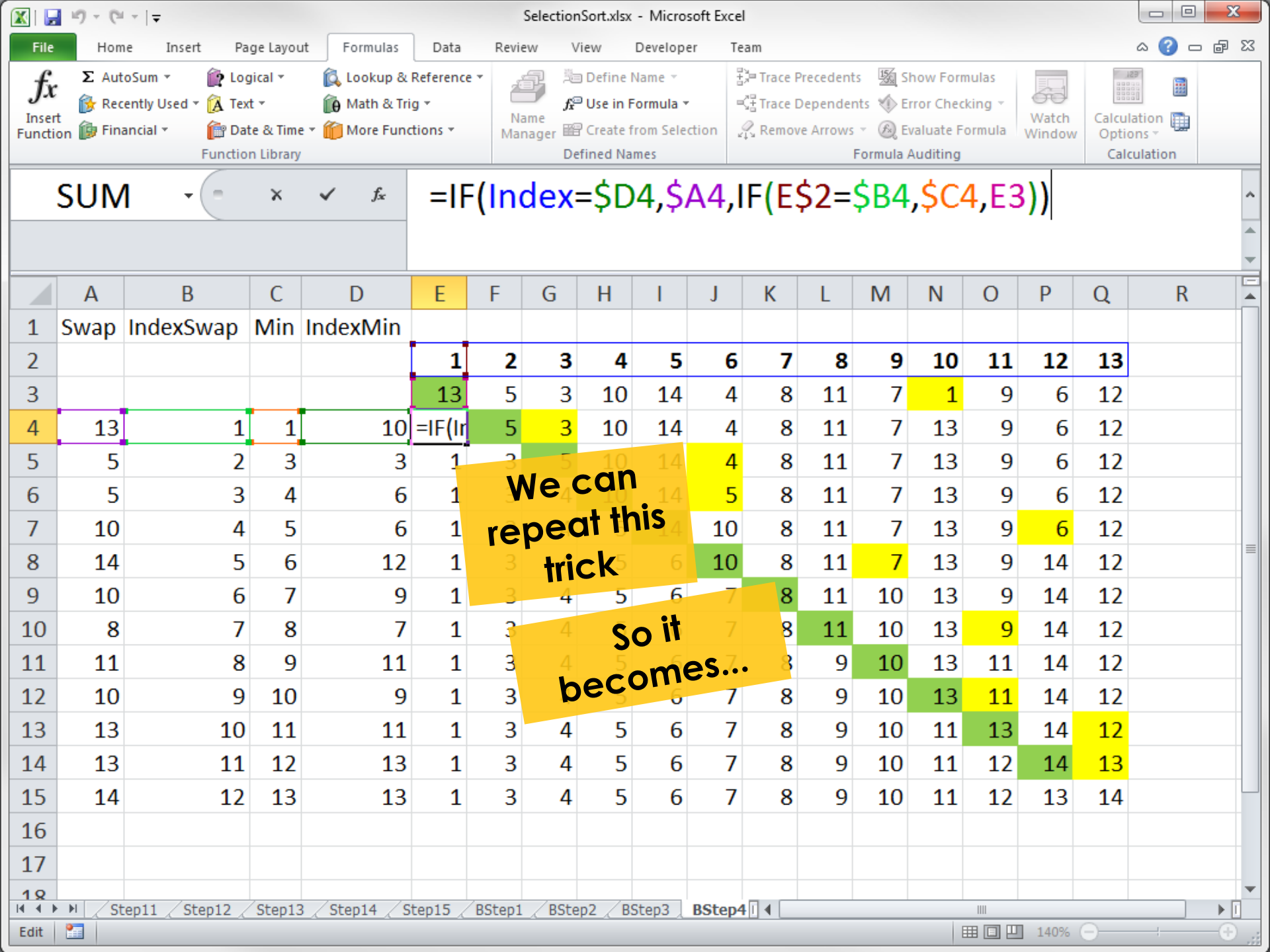
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Name Manager
Define Name
Use in Formula
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Defined Names
Trace Precedents
Trace Dependents
Remove Arrows
Show Formulas
Error Checking
Evaluate Formula
Formula Auditing
Watch Window
Calculation Options
Calculation
SUM
=IF(Index=$D4,$A4,IF(E$2=$B4,$C4,E3))
We can repeat this trick
So it becomes...
Step11
Step12
Step13
Step14
Step15
BStep1
BStep2
BStep3
BStep4
Edit
140%

SelectionSort.xlsx - Microsoft Excel

File | Home | Insert | Page Layout | Formulas | Data | Review | View | Developer | Team

Insert Function | AutoSum | Recently Used | Financial | Logical | Text | Date & Time | Lookup & Reference | Math & Trig | More Functions — Function Library

Name Manager | Define Name | Use in Formula | Create from Selection — Defined Names

Trace Precedents | Trace Dependents | Remove Arrows | Show Formulas | Error Checking | Evaluate Formula — Formula Auditing

Watch Window

Calculation Options — Calculation

SUM

=IF(Index=IndexMin,Swap,IF(Index=IndexSwap, Min,E3))

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
1	Swap	IndexSwap	Min	IndexMin														
2					1	2	3	4	5	6	7	8	9	10	11	12	13	
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15	14	12	13	13	1	3	4	5	6	7	8	9	10	11	12	13	14	
16																		
17																		

Isn't that nice?

Step11 | Step12 | Step13 | Step14 | Step15 | BStep1 | BStep2 | BStep3 | BStep4

Edit

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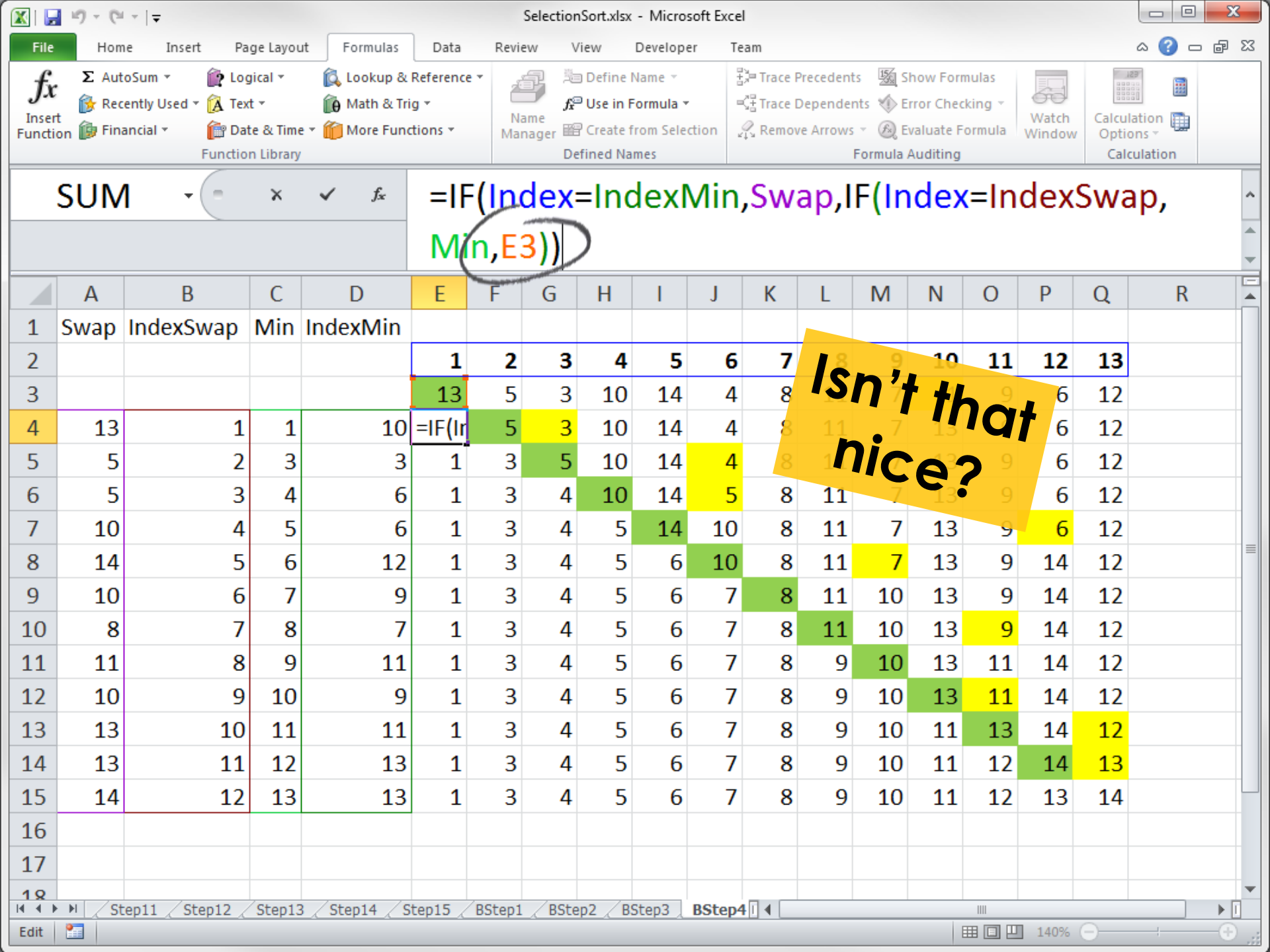

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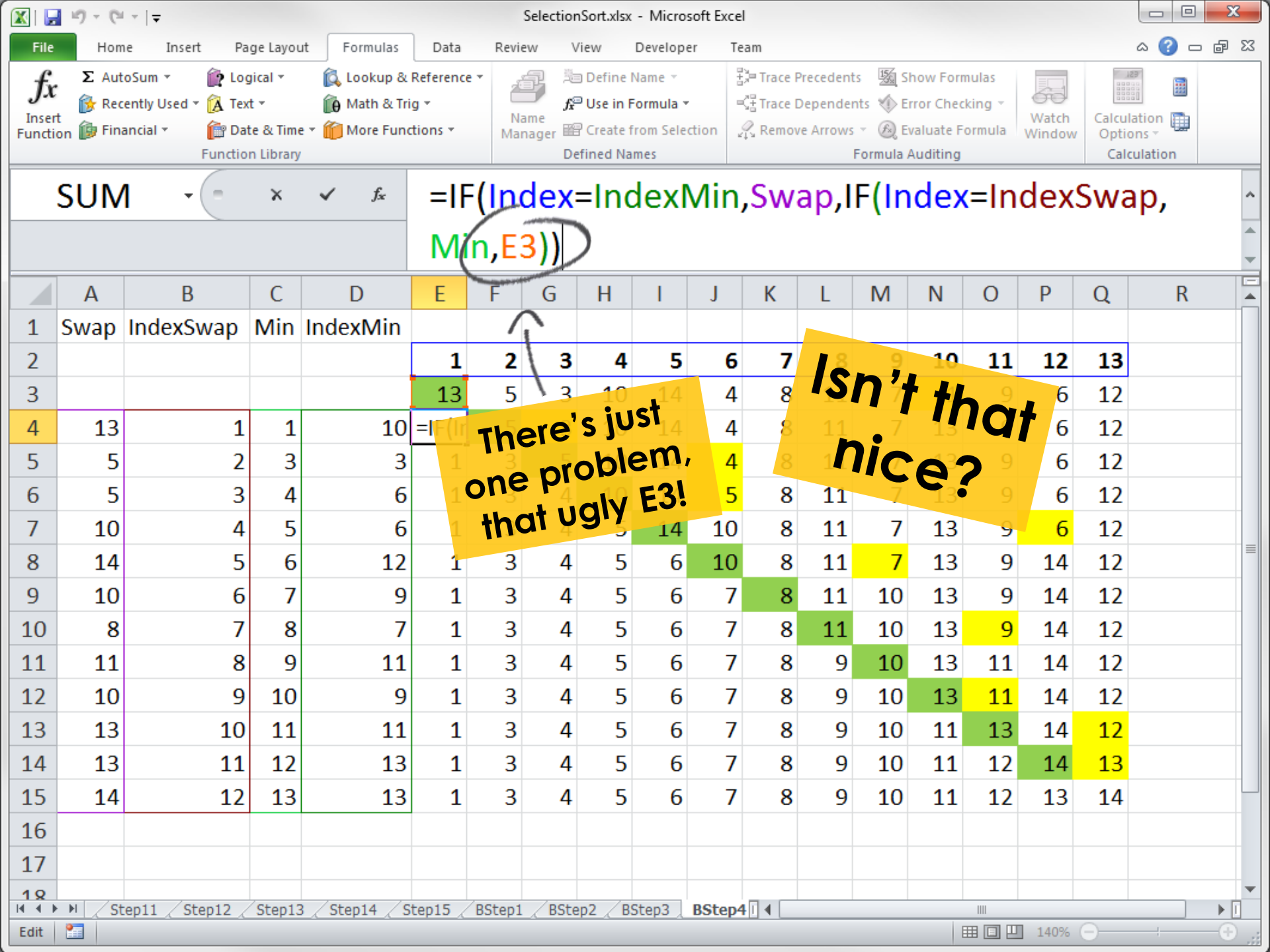

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16																		
17																		
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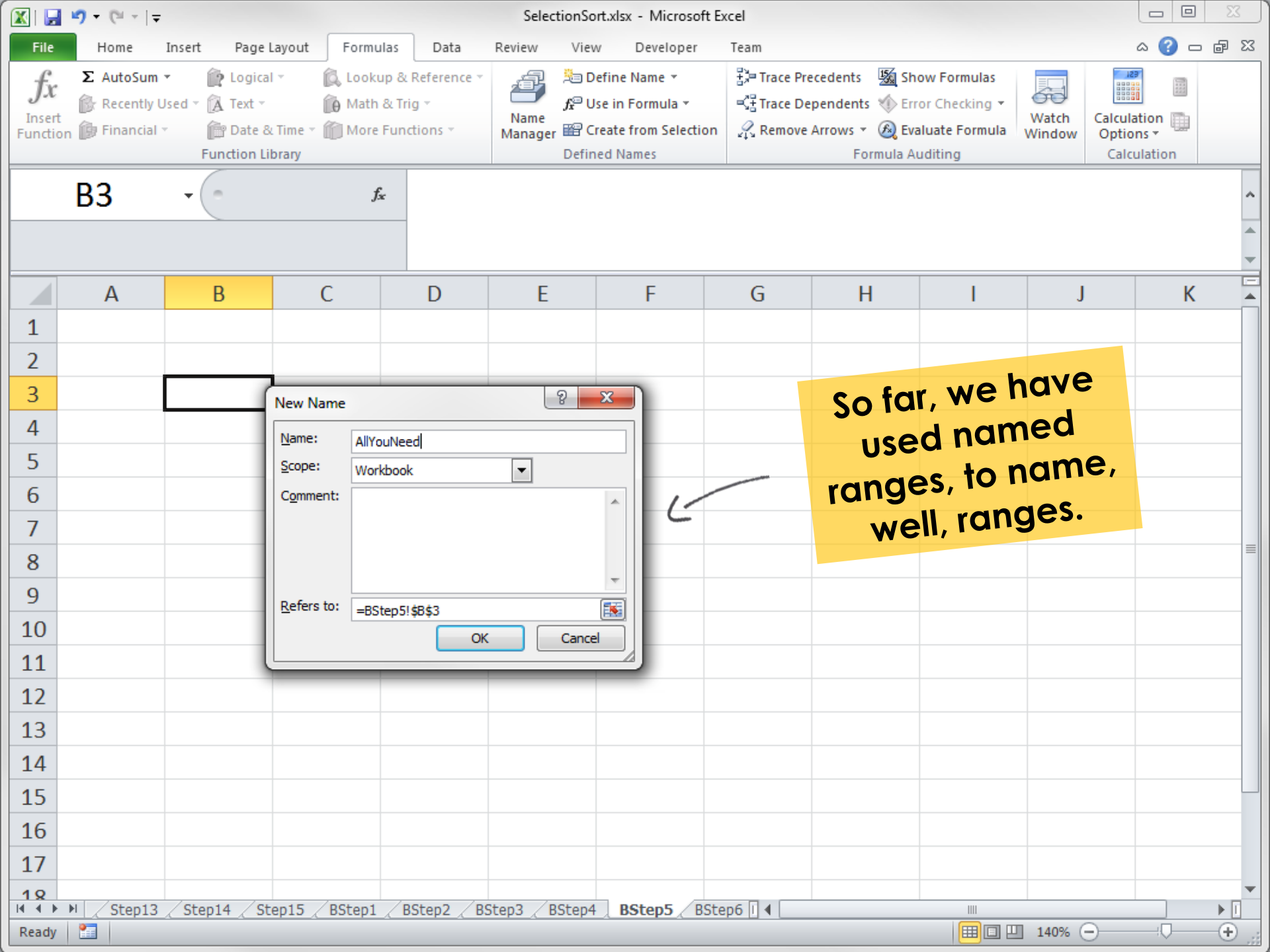
To fix that, we need to dive into named ranges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Create from Selection
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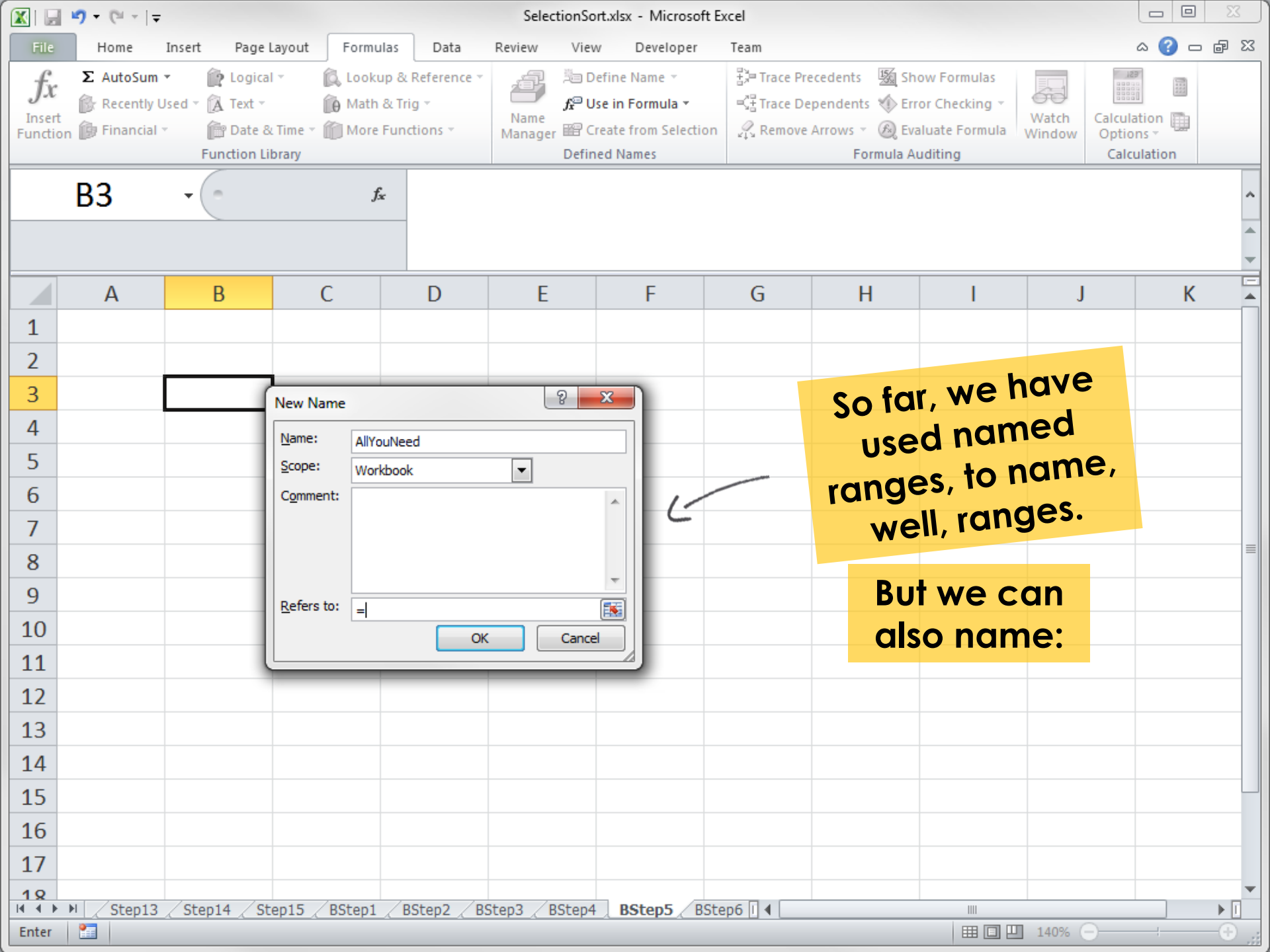
Calculation
B3
New Name
Name:
AllYouNeed
Scope:
Workbook
Comment:
Refers to:
=BStep5!$B$3
OK
Cancel
So far, we have used named ranges, to name, well, ranges.
Step13
Step14
Step15
BStep1
BStep2
BStep3
BStep4
BStep5
BStep6
Ready
140%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Create from Selection
Defined Names
Trace Precedents
Trace Dependents
Remove Arrows
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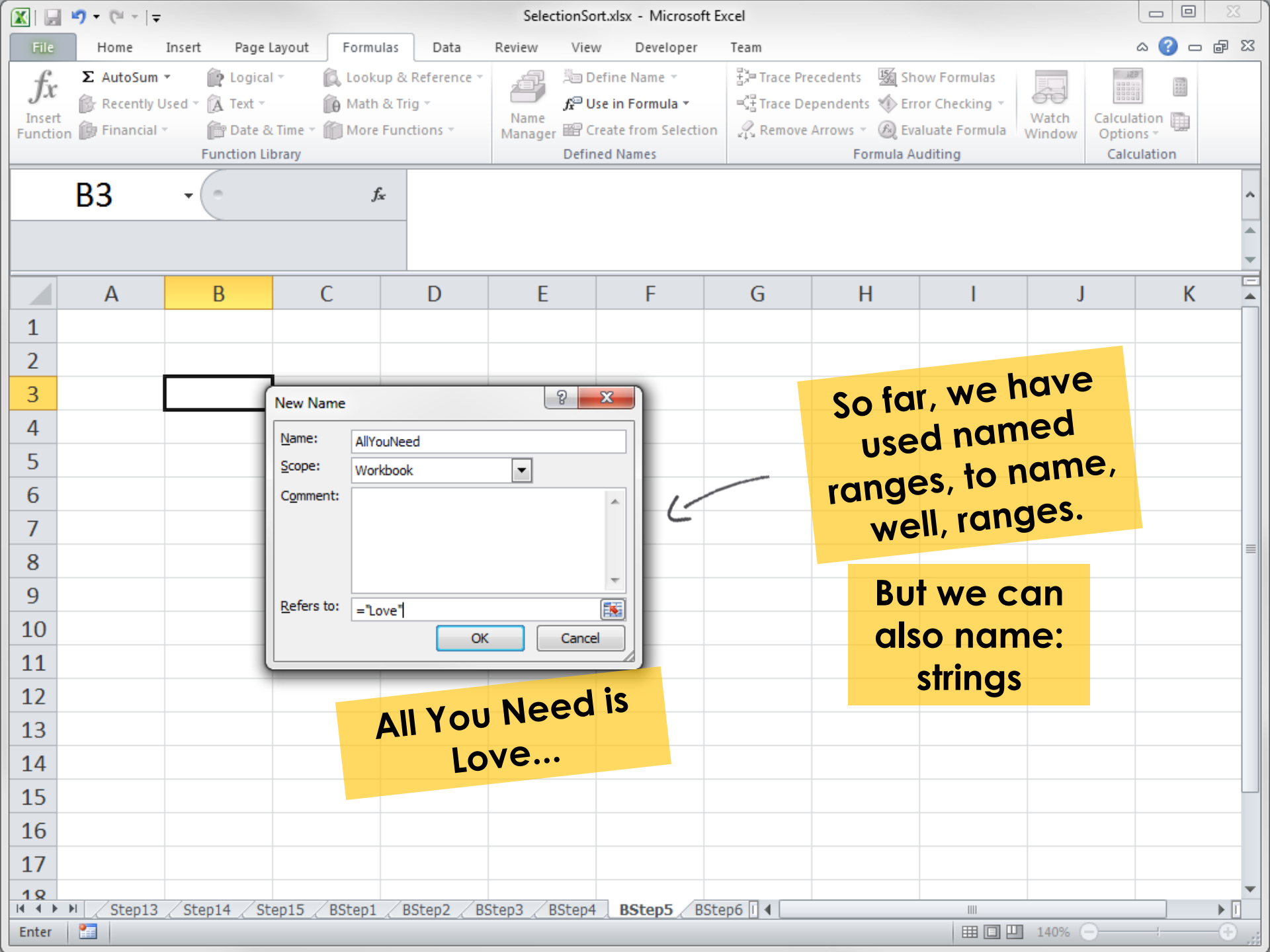
Formula Auditing
Watch Window
Calculation Options
Calculation
B3
New Name
Name:
AllYouNeed
Scope:
Workbook
Comment:
Refers to:
=
OK
Cancel
So far, we have used named ranges, to name, well, ranges.
But we can also name:
Step13
Step14
Step15
BStep1
BStep2
BStep3
BStep4
BStep5
BStep6
Enter
140%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Trace Precedents
Trace Dependents
Remove Arrows
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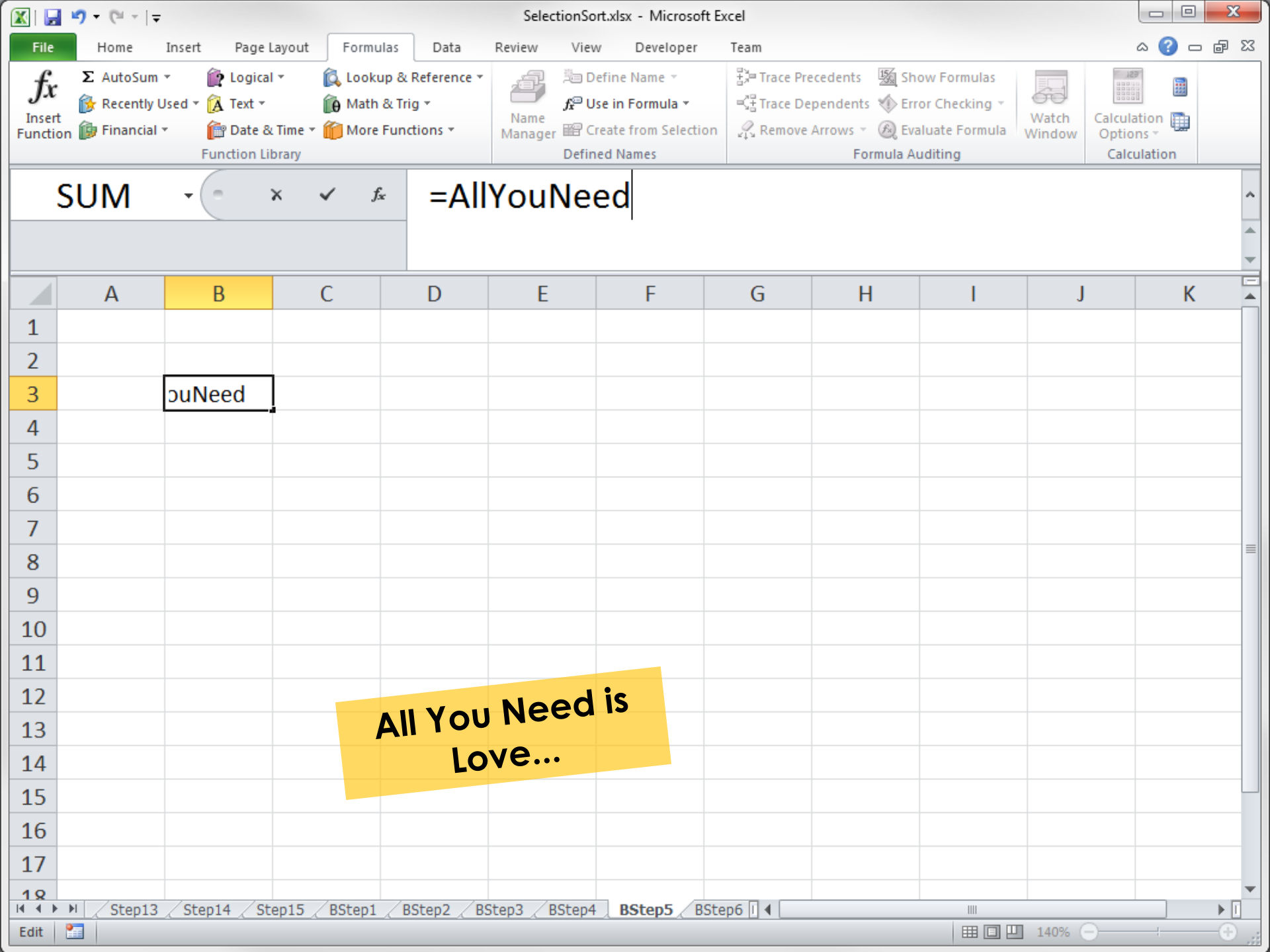
Error Checking
Evaluate Formula
Formula Auditing
Watch Window
Calculation Options
Calculation
B3
A B C D E F G H I J K
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
New Name
Name: AllYouNeed
Scope: Workbook
Comment:
Refers to: ="Love"
OK
Cancel
So far, we have used named ranges, to name, well, ranges.
But we can also name: strings
All You Need is Love...
Step13 Step14 Step15 BStep1 BStep2 BStep3 BStep4 BStep5 BStep6
Enter
140%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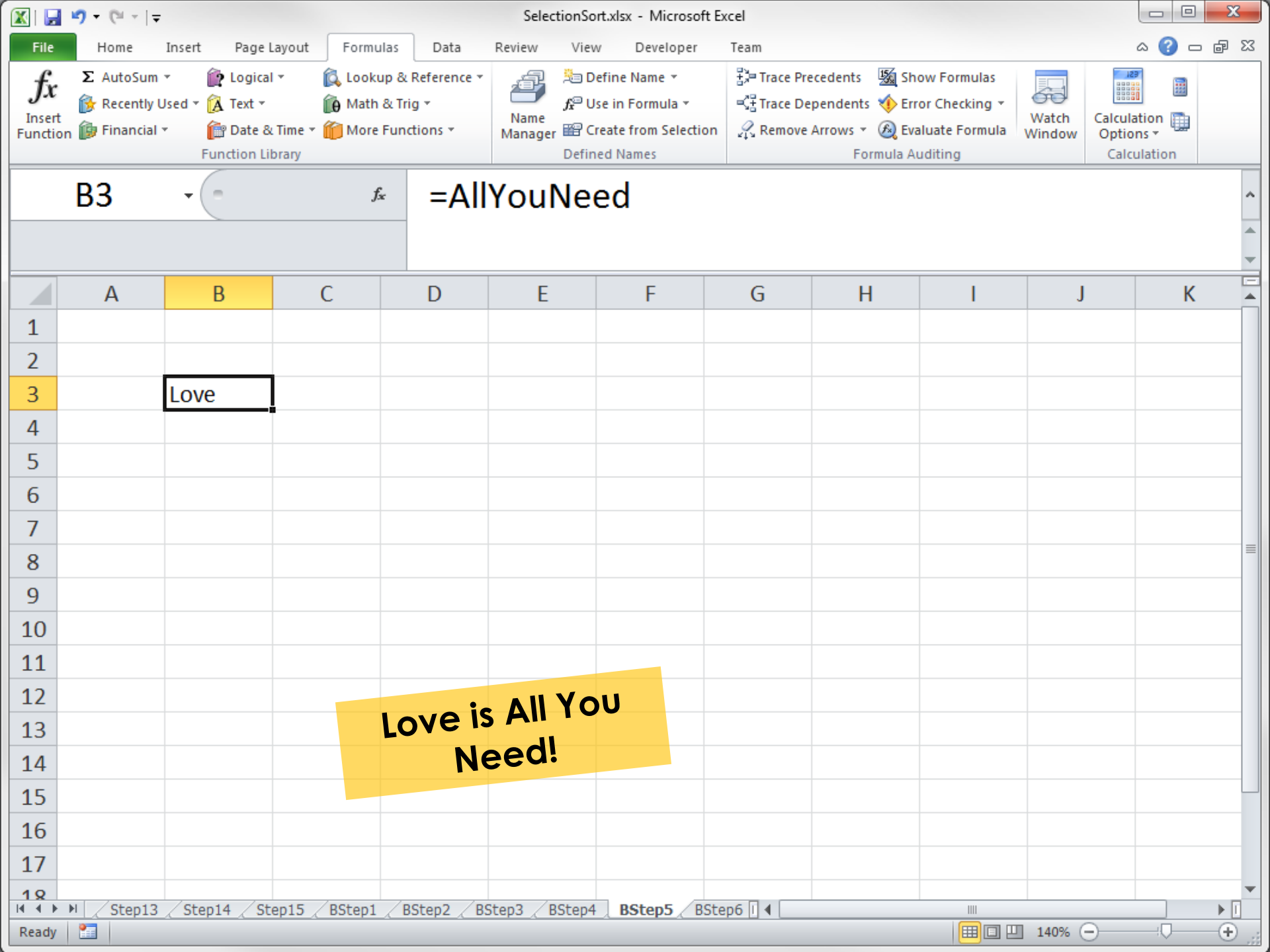
More Functions
Function Library
Name Manager
Define Name
Use in Formula
Create from Selection
Defined Names
Trace Precedents
Trace Dependents
Remove Arrows
Show Formulas
Error Checking
Evaluate Formula
Formula Auditing
Watch Window
Calculation Options
Calculation
SUM
=AllYouNeed
ouNeed
All You Need is Love...
Step13
Step14
Step15
BStep1
BStep2
BStep3
BStep4
BStep5
BStep6
Edit
140%


SelectionSort.xlsx - Microsoft Excel
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Calculation
B3
=AllYouNeed
A
B
C
D
E
F
G
H
I
J
K
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
Love
Love is All You Need!
Step13
Step14
Step15
BStep1
BStep2
BStep3
BStep4
BStep5
BStep6
Ready
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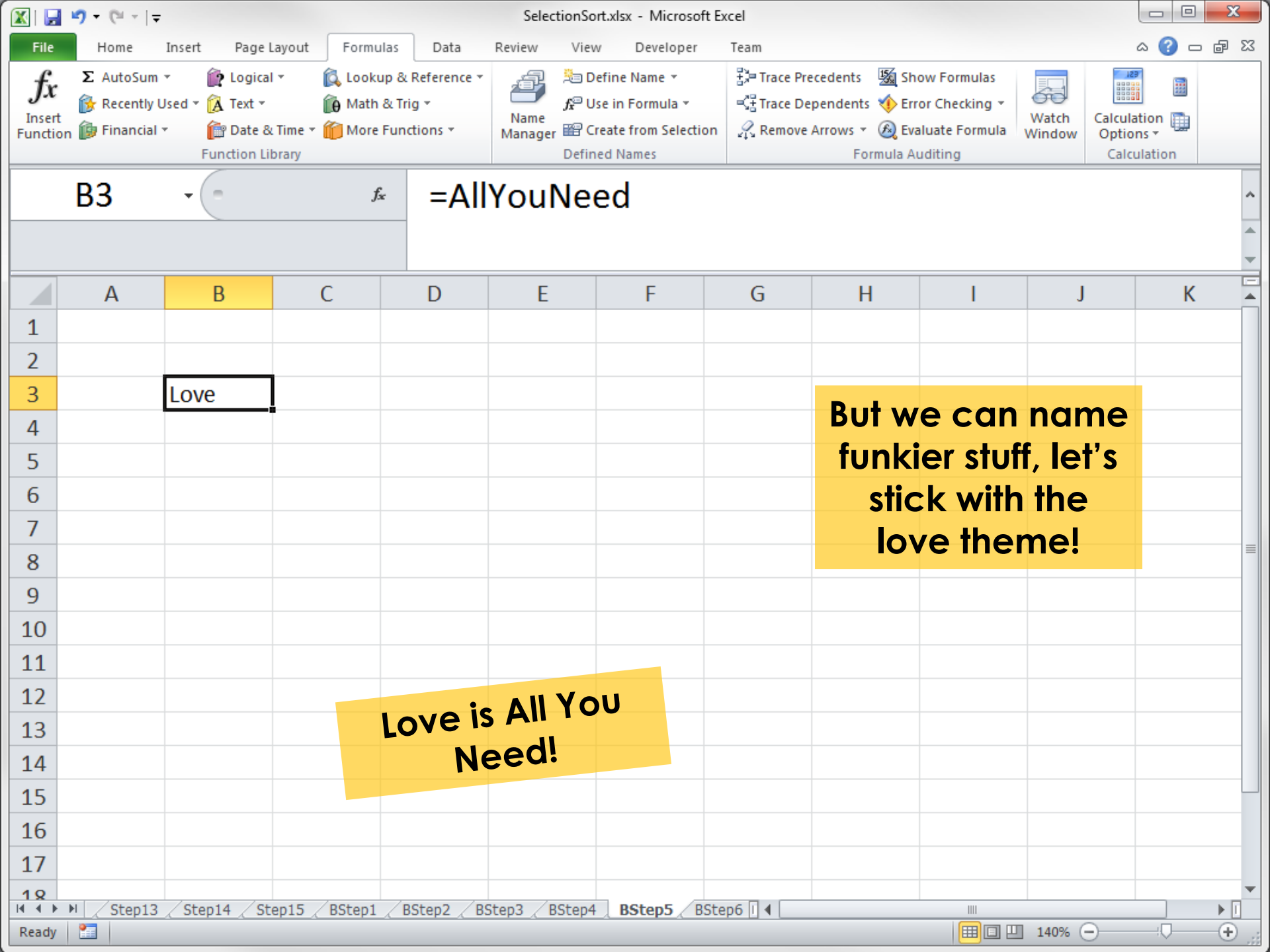
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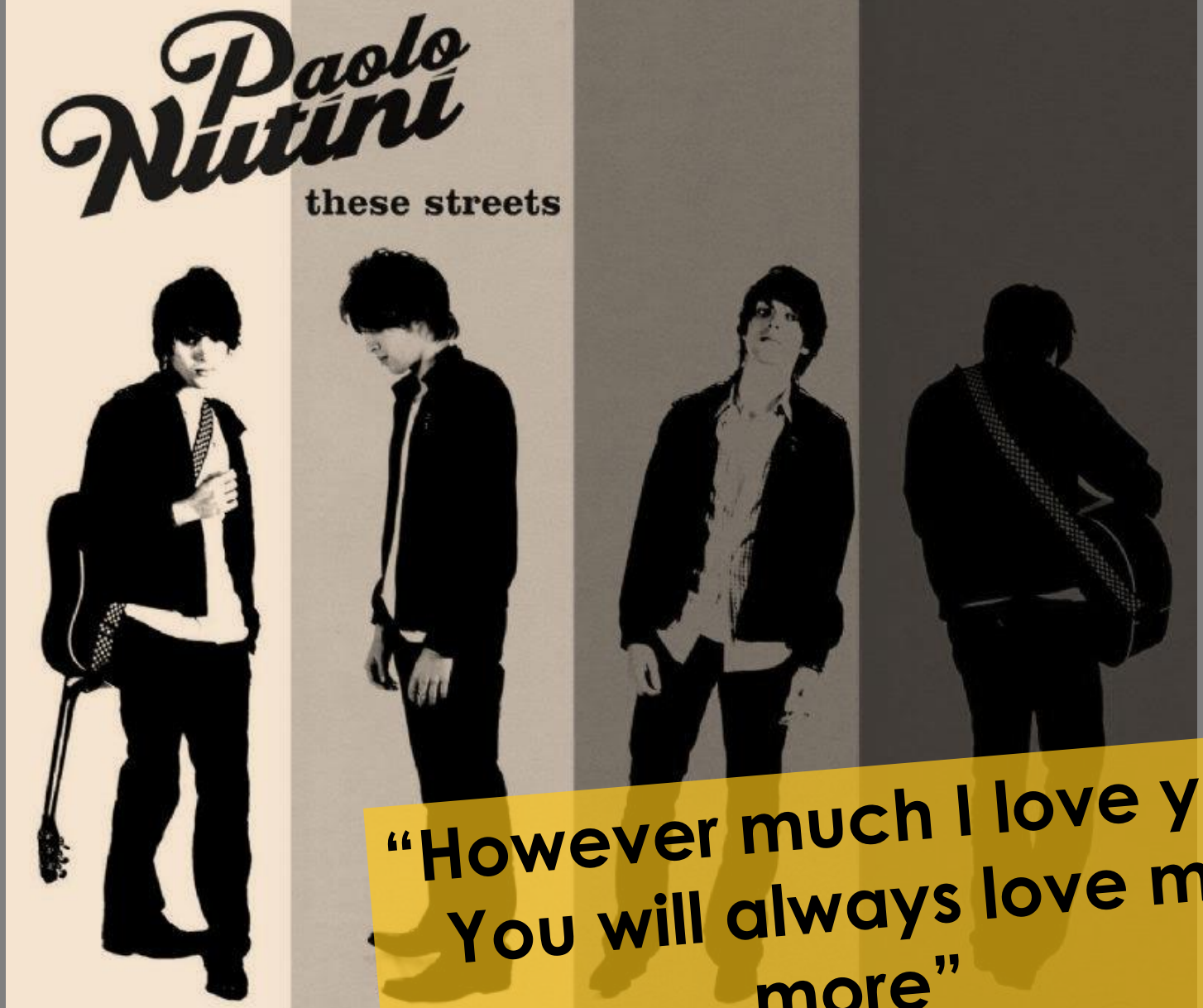
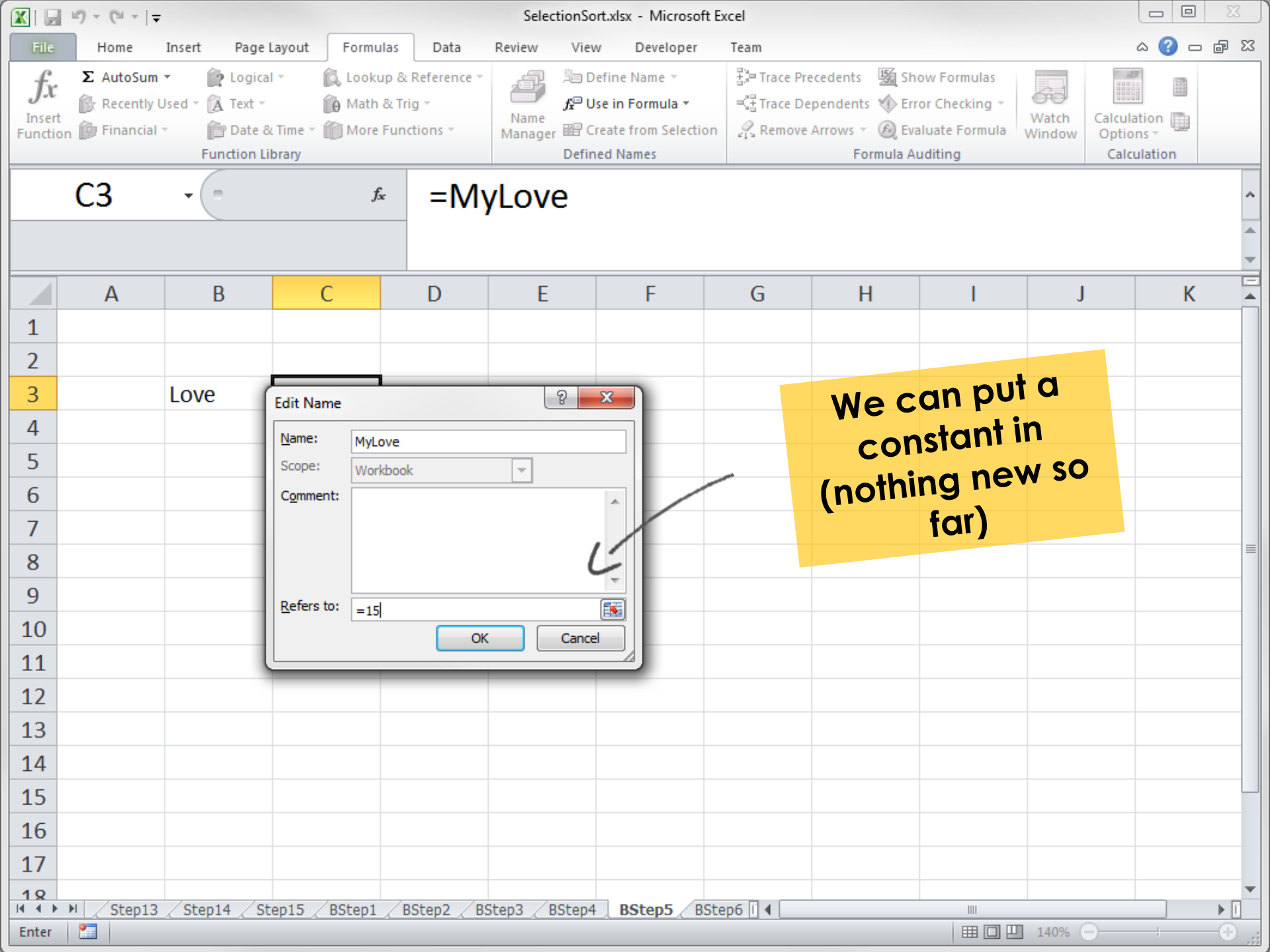
H
I
J
K
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
Love
But we can name funkier stuff, let's stick with the love theme!
Love is All You Need!
Step13
Step14
Step15
BStep1
BStep2
BStep3
BStep4
BStep5
BStep6
Ready
140%



“However much I love you, You will always love me more”

This too can be expressed with a named range

"However much I love you, You will always love me more"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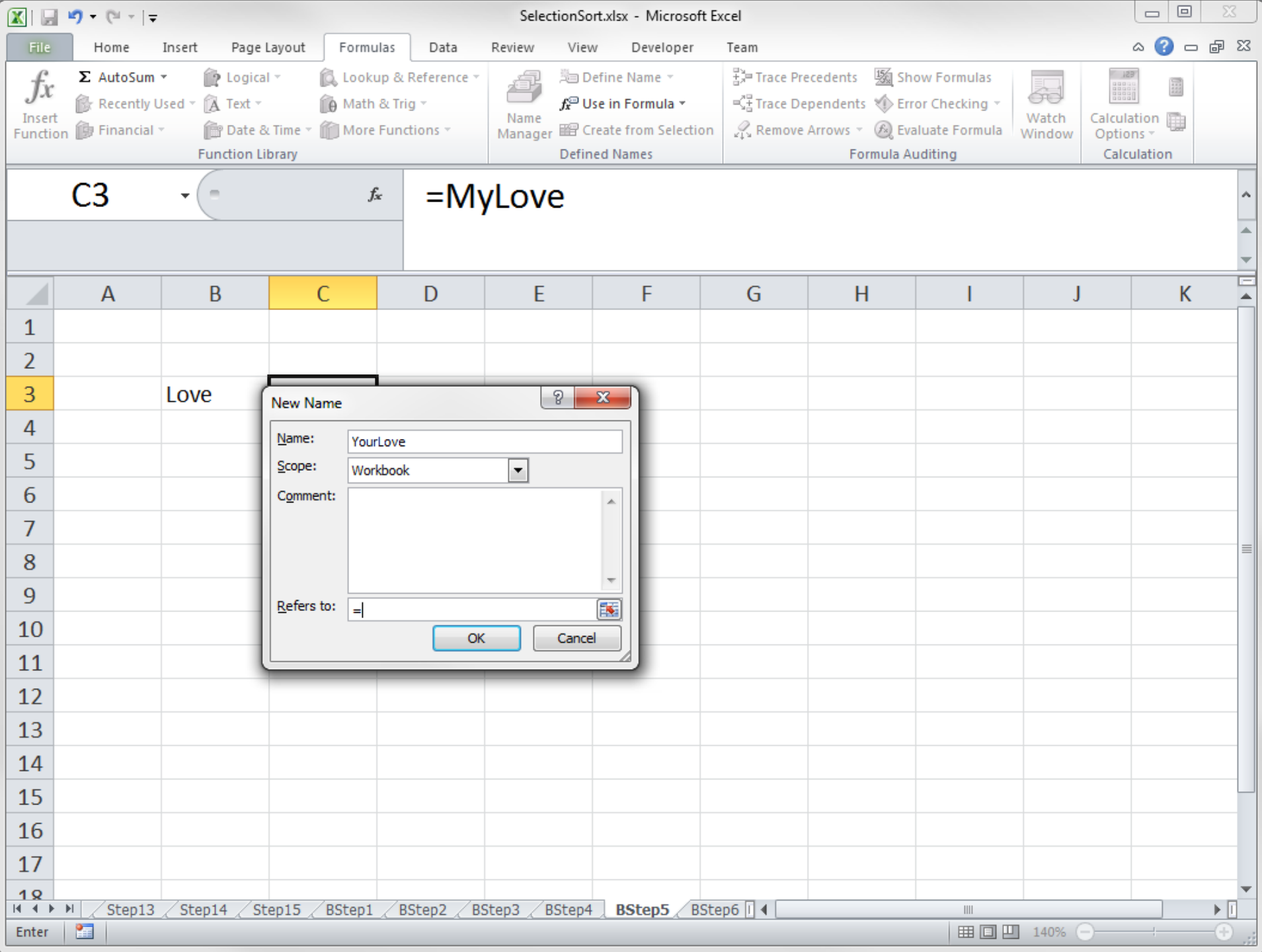
Calculation Options
Calculation
C3
=MyLove
Love
Edit Name
Name: MyLove
Scope: Workbook
Comment:
Refers to: =15
OK
Cancel
We can put a constant in (nothing new so far)
Step13
Step14
Step15
BStep1
BStep2
BStep3
BStep4
BStep5
BStep6
Enter
140%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Calculation
C3
=MyLove
Love
New Name
Name:
YourLove
Scope:
Workbook
Comment:
Refers to:
=
OK
Cancel
Step13
Step14
Step15
BStep1
BStep2
BStep3
BStep4
BStep5
BStep6
Enter
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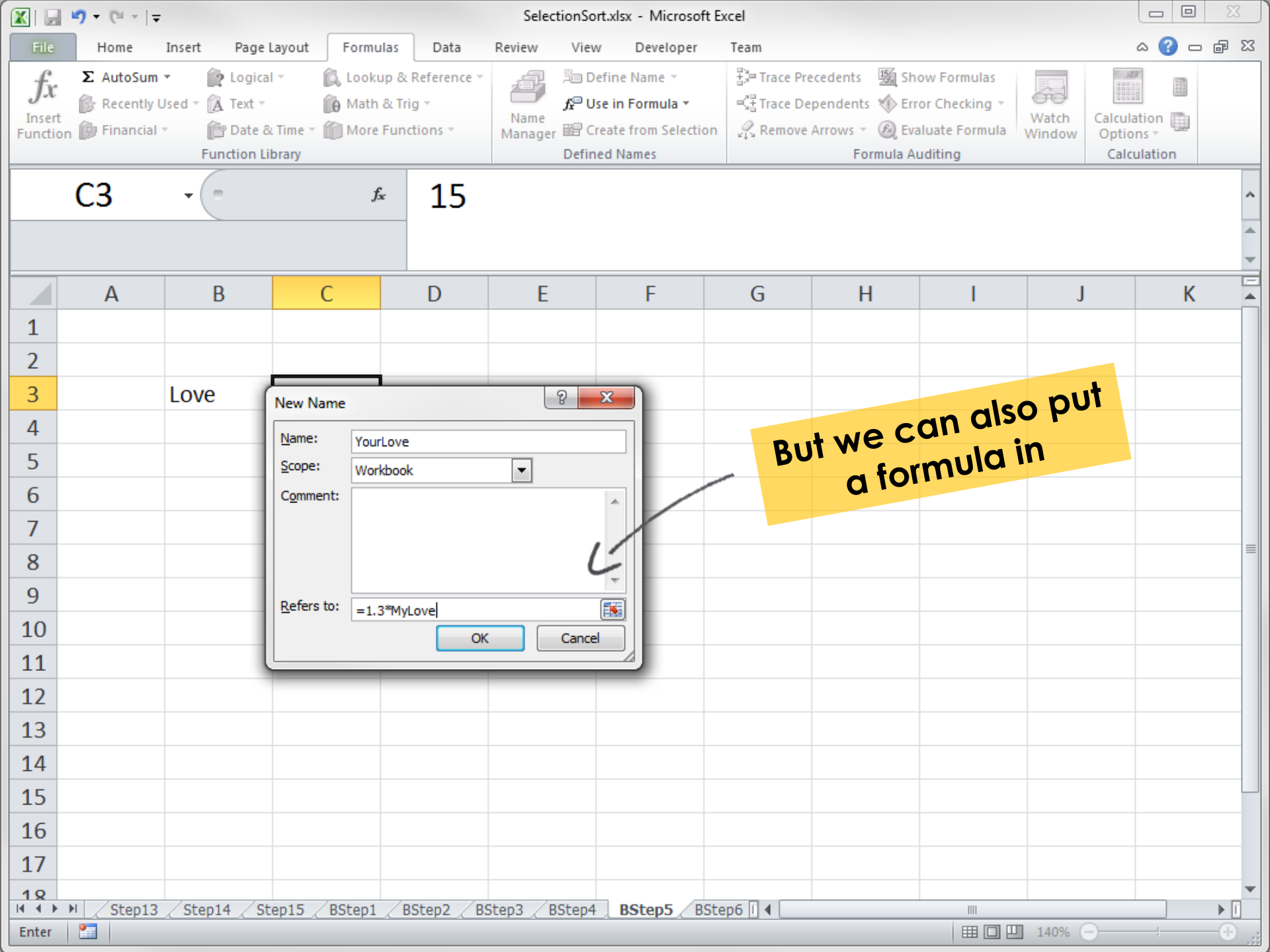
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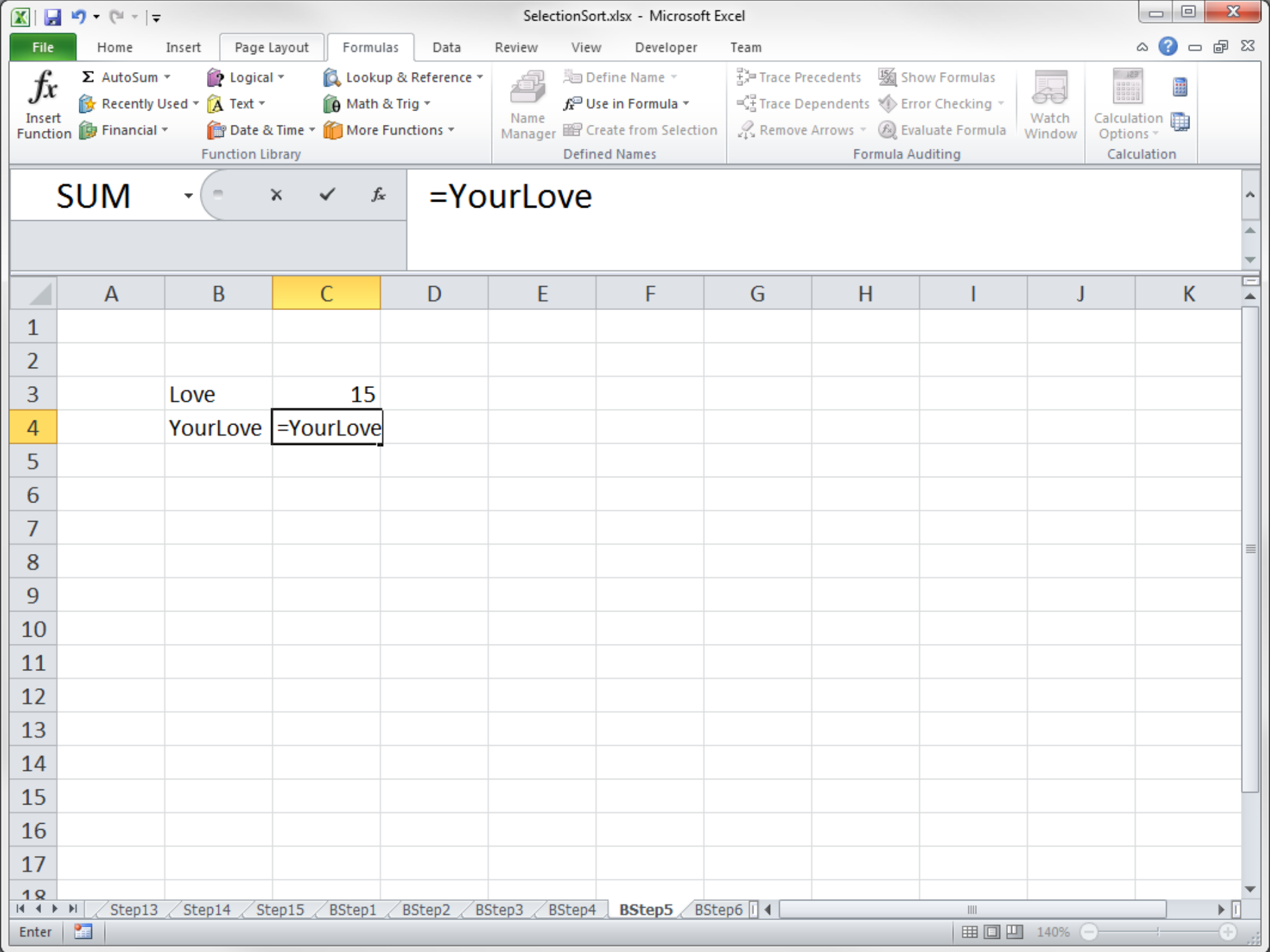
Formula Auditing
Watch Window
Calculation Options
Calculation
C3
15
Love
New Name
Name:
YourLove
Scope:
Workbook
Comment:
Refers to:
=1.3*MyLove
OK
Cancel
But we can also put a formula in
Step13
Step14
Step15
BStep1
BStep2
BStep3
BStep4
BStep5
BStep6
Enter
140%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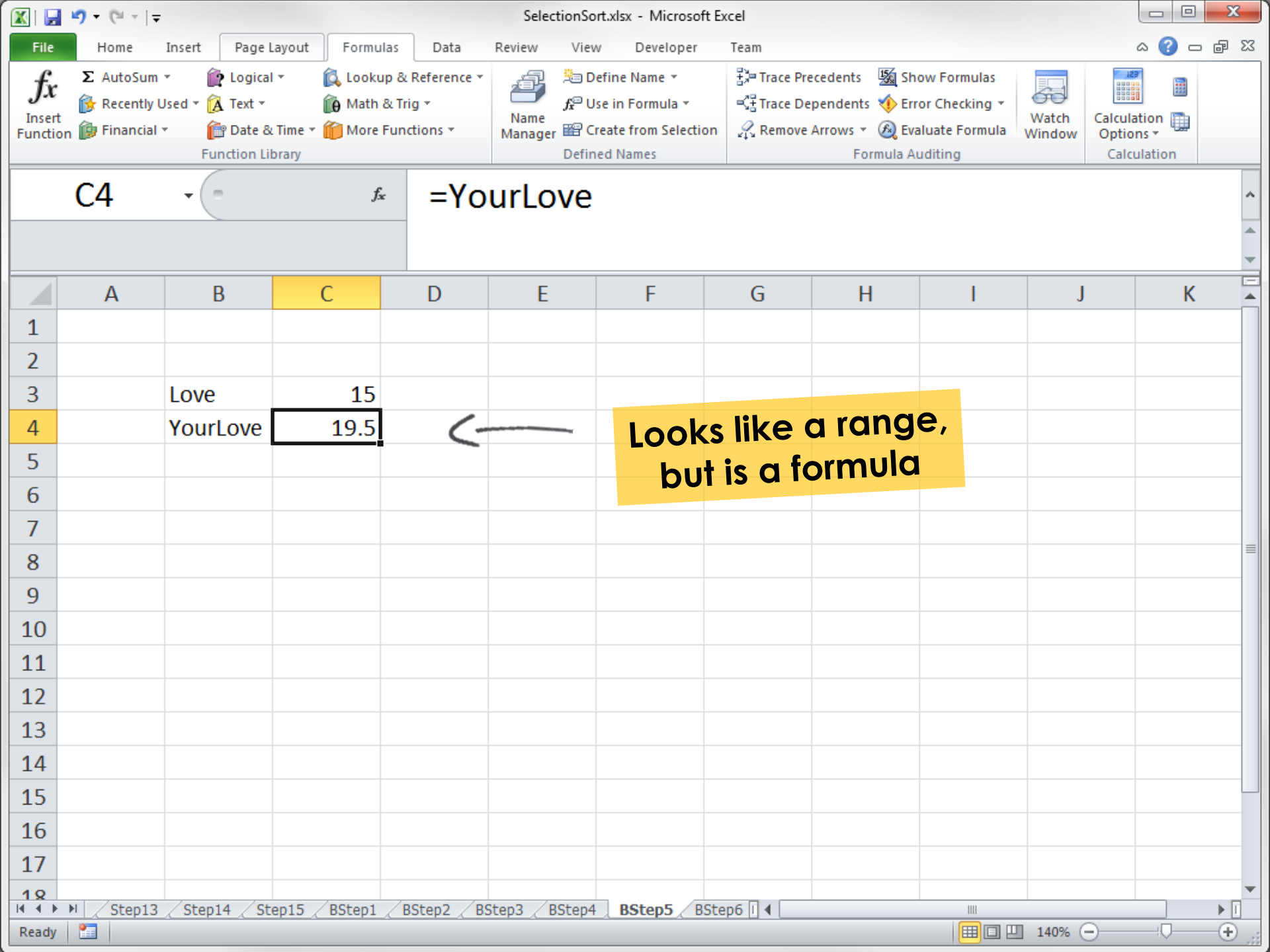
Watch Window
Calculation Options
Calculation
SUM
=YourLove
A B C D E F G H I J K
1
2
3 Love 15
4 YourLove =YourLove
5 6 7 8 9 10 11 12 13 14 15 16 17 18
Step13 Step14 Step15 BStep1 BStep2 BStep3 BStep4 BStep5 BStep6
Enter
140%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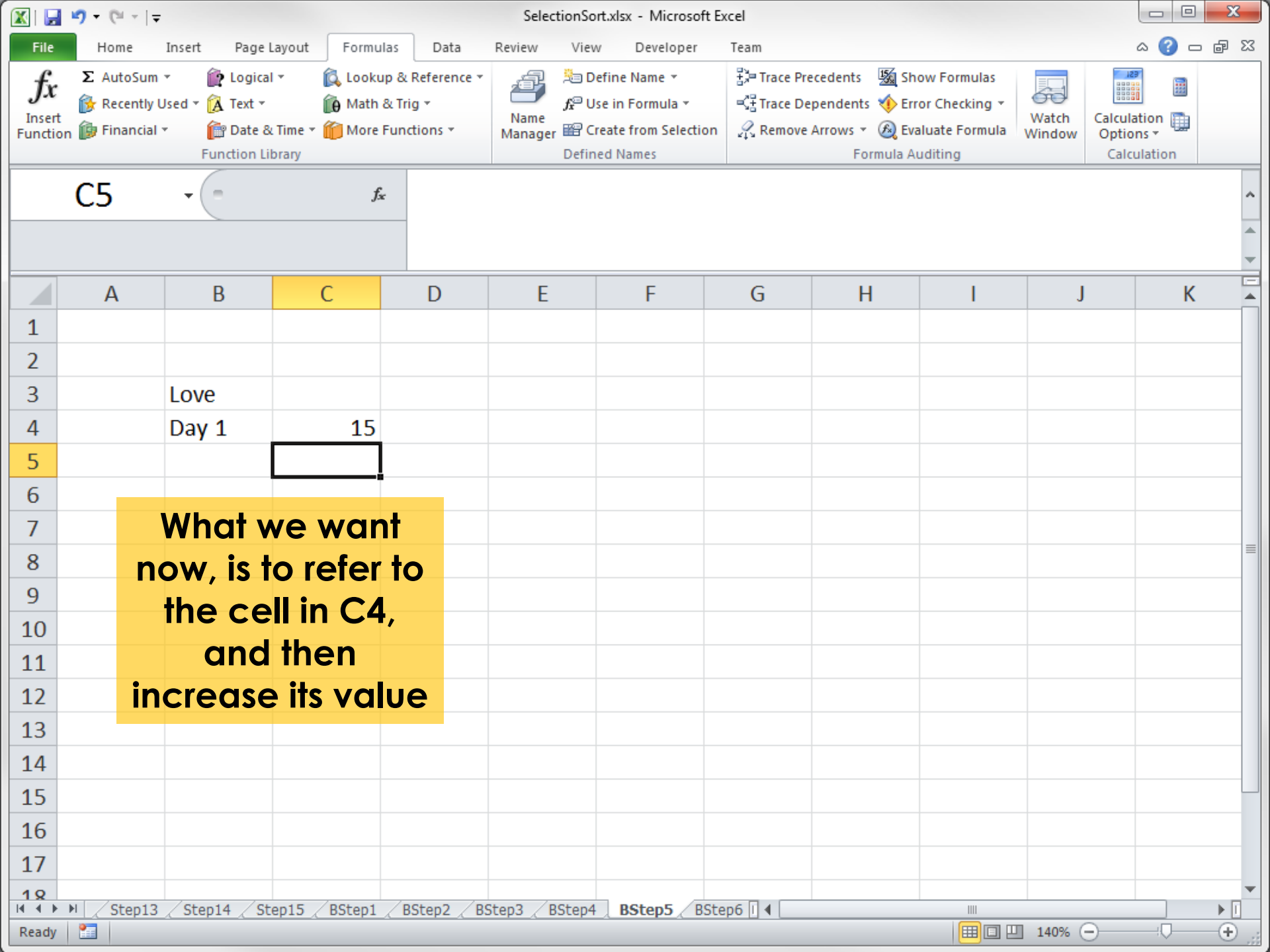
Trace Dependents
Remove Arrows
Show Formulas
Error Checking
Evaluate Formula
Formula Auditing
Watch Window
Calculation Options
Calculation
C4
=YourLove
A
B
C
D
E
F
G
H
I
J
K
1
2
3
Love
15
4
YourLove
19.5
5
6
7
8
9
10
11
12
13
14
15
16
17
Looks like a range, but is a formula
Step13
Step14
Step15
BStep1
BStep2
BStep3
BStep4
BStep5
BStep6
Ready
140%


armin van buuren
feat. racoon love you more
"Everyday I love you more"
Named ranges got you covered again!
ARMIN VAN BUUREN
.org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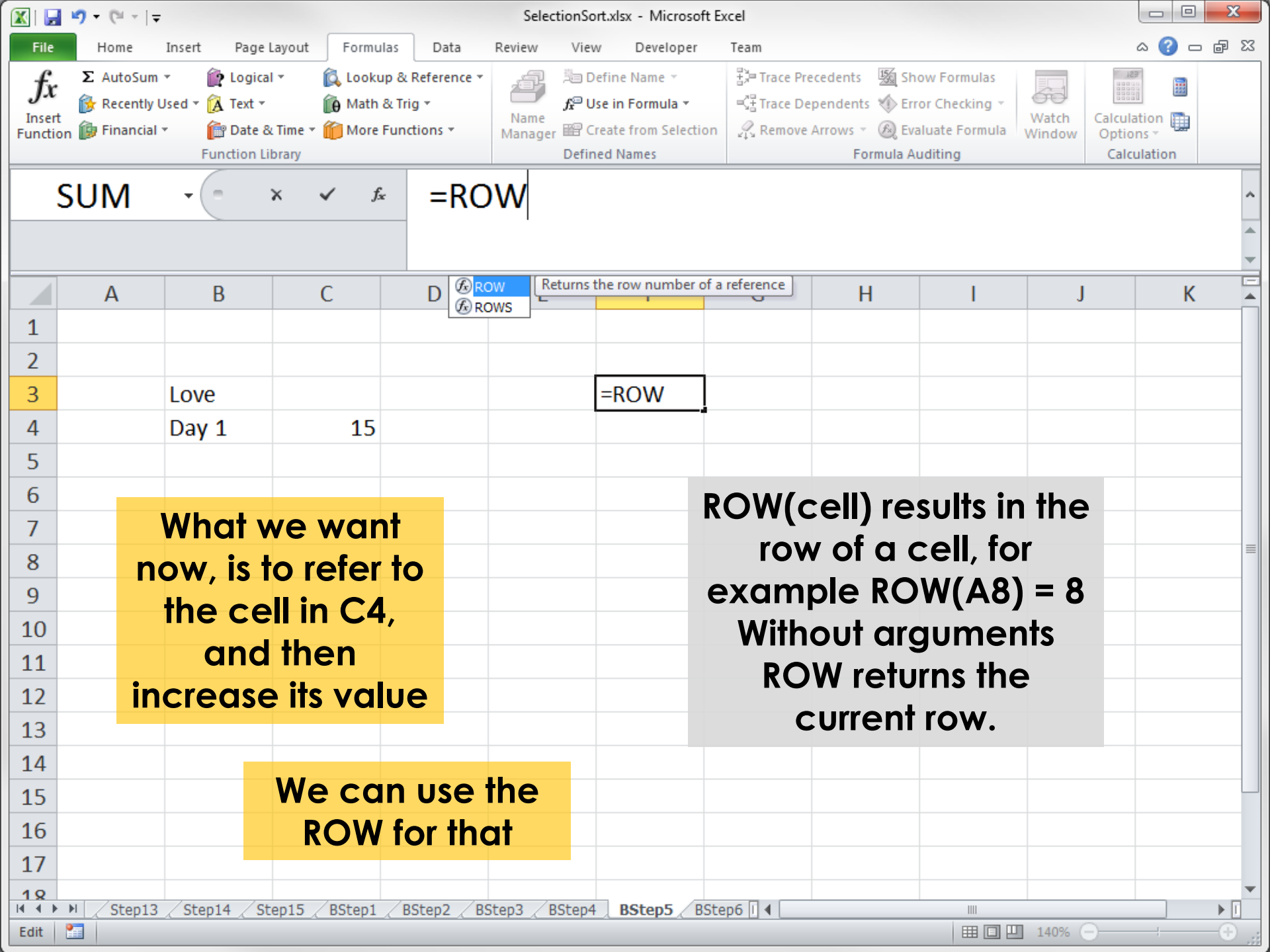
Trace Dependents
Remove Arrows
Show Formulas
Error Checking
Evaluate Formula
Formula Auditing
Watch Window
Calculation Options
Calculation
C5
A B C D E F G H I J K
1
2
3 Love
4 Day 1 15
5
6
7
8
9
10
11
12
13
14
15
16
17
18
What we want now, is to refer to the cell in C4, and then increase its value
Step13 Step14 Step15 BStep1 BStep2 BStep3 BStep4 BStep5 BStep6
Ready
140%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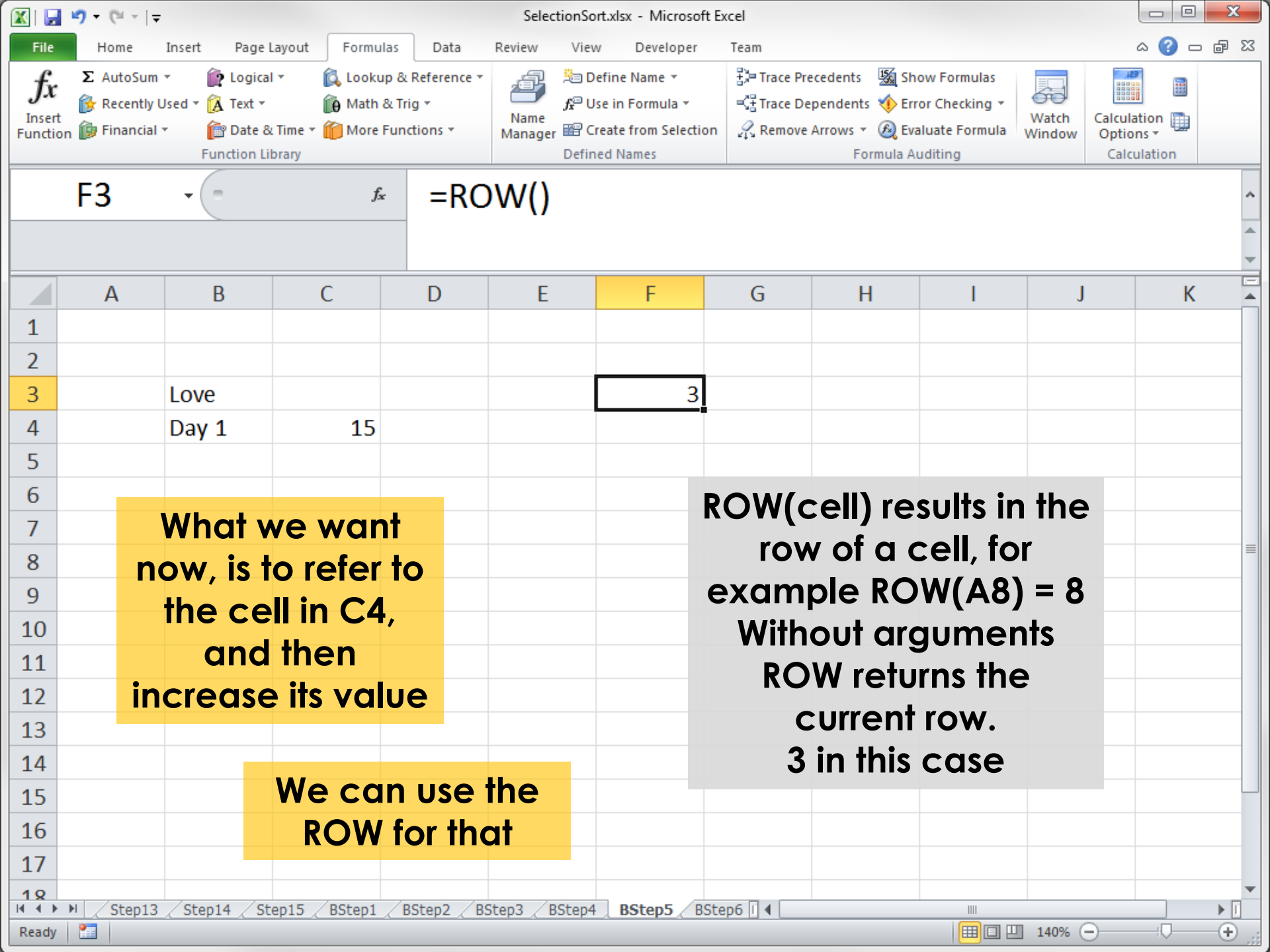
Defined Names
Trace Precedents
Trace Dependents
Remove Arrows
Show Formulas
Error Checking
Evaluate Formula
Formula Auditing
Watch Window
Calculation Options
Calculation
SUM
=ROW
ROW
ROWS
Returns the row number of a reference
Love
Day 1
15
=ROW
What we want now, is to refer to the cell in C4, and then increase its value
ROW(cell) results in the row of a cell, for example ROW(A8) = 8 Without arguments ROW returns the current row.
We can use the ROW for that
Step13
Step14
Step15
BStep1
BStep2
BStep3
BStep4
BStep5
BStep6
Edit
140%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Use in Formula
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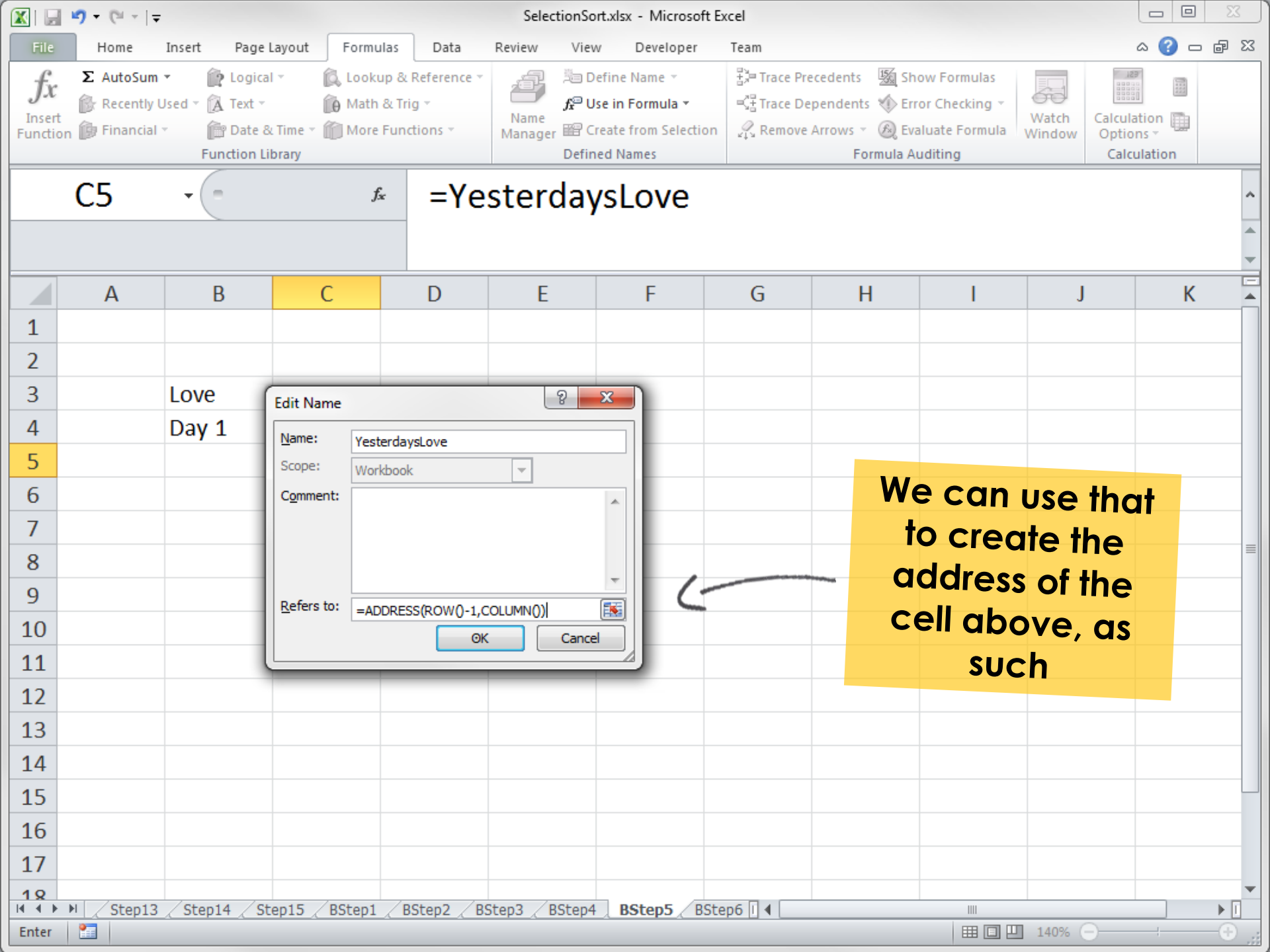
Defined Names
Trace Precedents
Trace Dependents
Remove Arrows
Show Formulas
Error Checking
Evaluate Formula
Formula Auditing
Watch Window
Calculation Options
Calculation
F3
=ROW()
A B C D E F G H I J K
1
2
3 Love 3
4 Day 1 15
5
6
7
8
9
10
11
12
13
14
15
16
17
18
What we want now, is to refer to the cell in C4, and then increase its value
We can use the ROW for that
ROW(cell) results in the row of a cell, for example ROW(A8) = 8
Without arguments ROW returns the current row.
3 in this case
Step13
Step14
Step15
BStep1
BStep2
BStep3
BStep4
BStep5
BStep6
Ready
140%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Defined Names
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Trace Dependents
Remove Arrows
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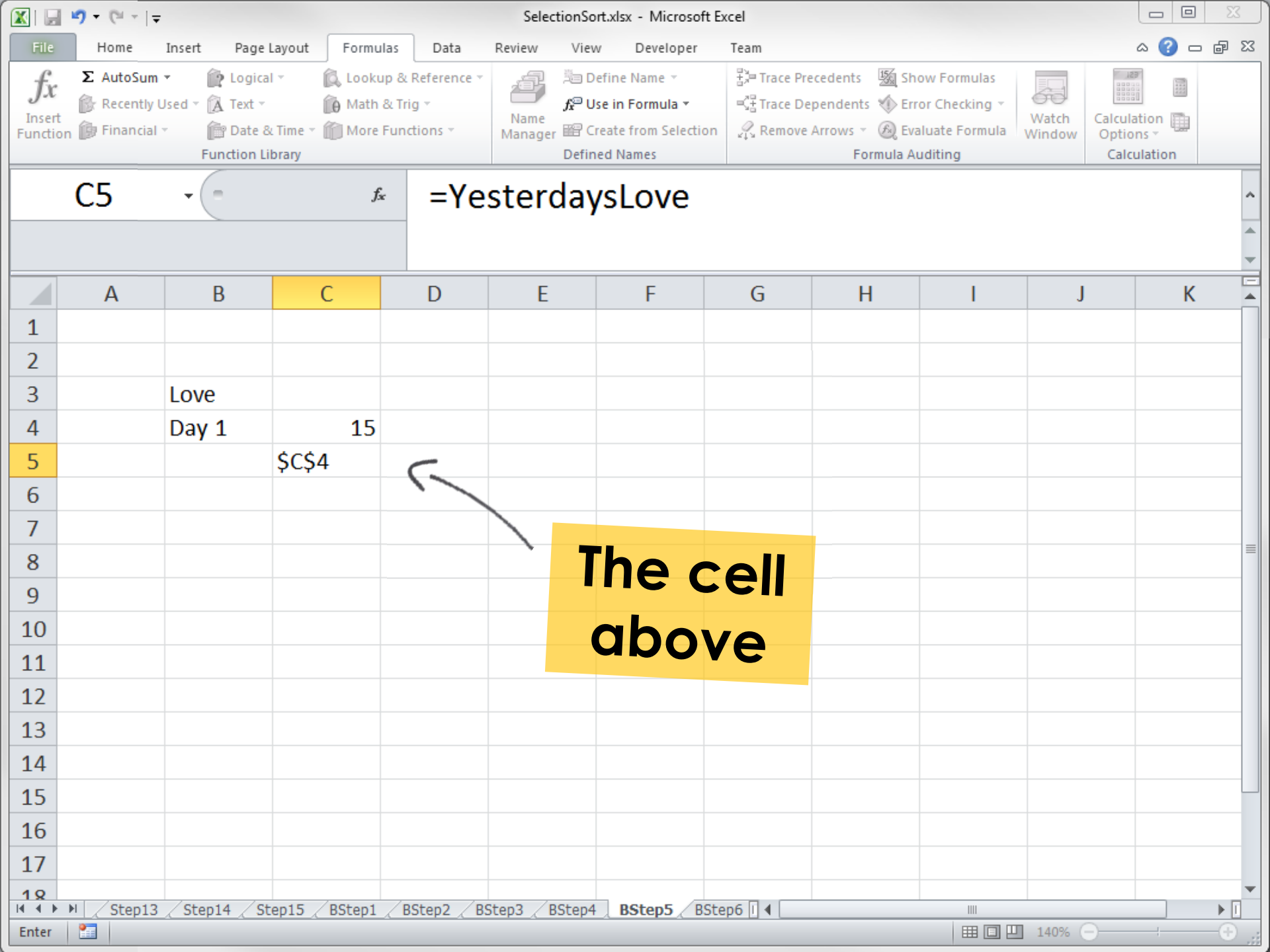
Error Checking
Evaluate Formula
Formula Auditing
Watch Window
Calculation Options
Calculation
C5
=YesterdaysLove
Love
Day 1
Edit Name
Name: YesterdaysLove
Scope: Workbook
Comment:
Refers to: =ADDRESS(ROW()-1,COLUMN())
OK
Cancel
We can use that to create the address of the cell above, as such
Step13
Step14
Step15
BStep1
BStep2
BStep3
BStep4
BStep5
BStep6
Enter
140%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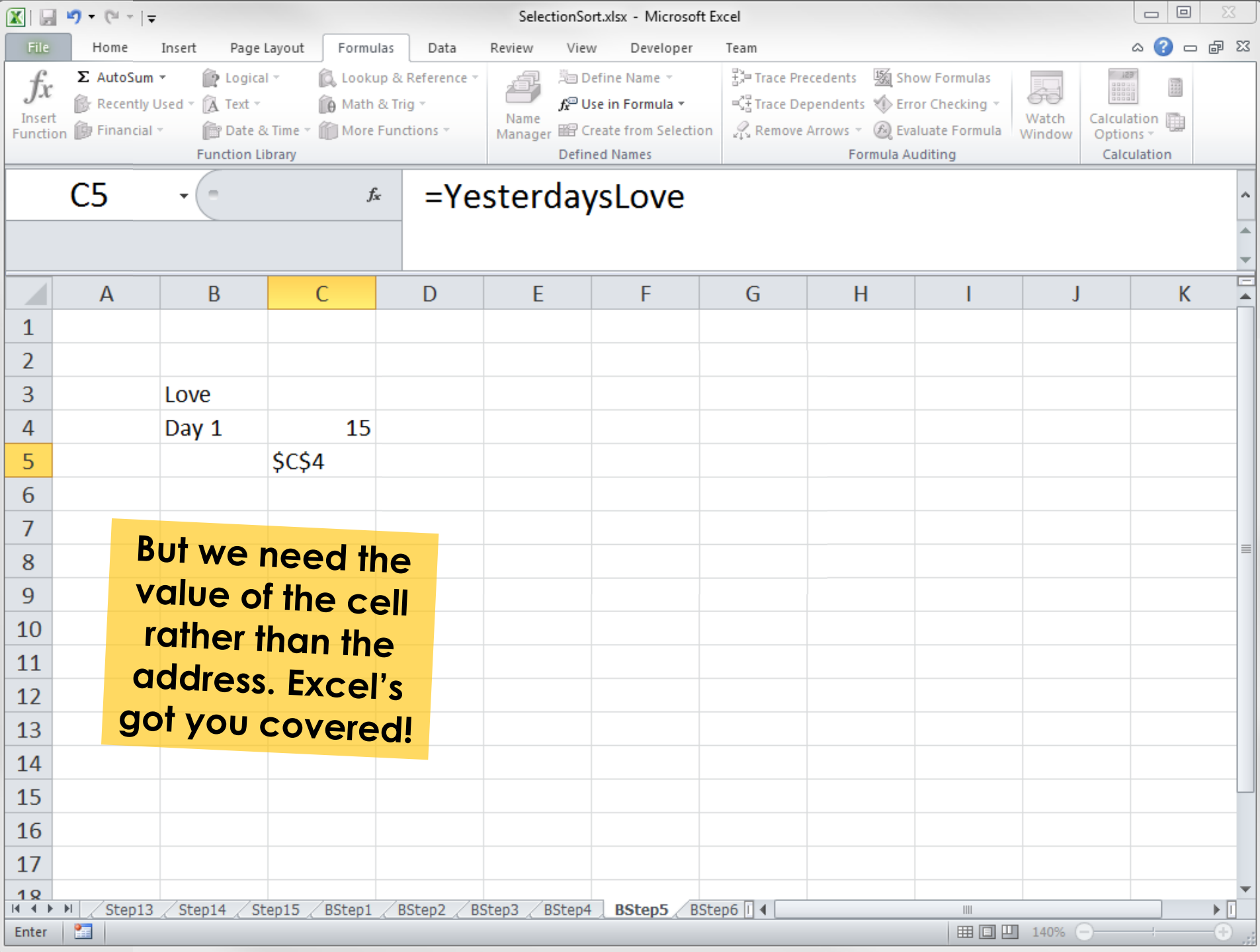
Calculation
C5
=YesterdaysLove
A B C D E F G H I J K
1
2
3 Love
4 Day 1 15
5 $C$4
6
7
8
9
10
11
12
13
14
15
16
17
The cell above
Step13 Step14 Step15 BStep1 BStep2 BStep3 BStep4 BStep5 BStep6
Enter
140%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Calculation
C5
=YesterdaysLove
A B C D E F G H I J K
1
2
3 Love
4 Day 1 15
5 $C$4
6
7
8
9
10
11
12
13
14
15
16
17
But we need the value of the cell rather than the address. Excel's got you covered!
Step13 Step14 Step15 BStep1 BStep2 BStep3 BStep4 BStep5 BStep6
Enter
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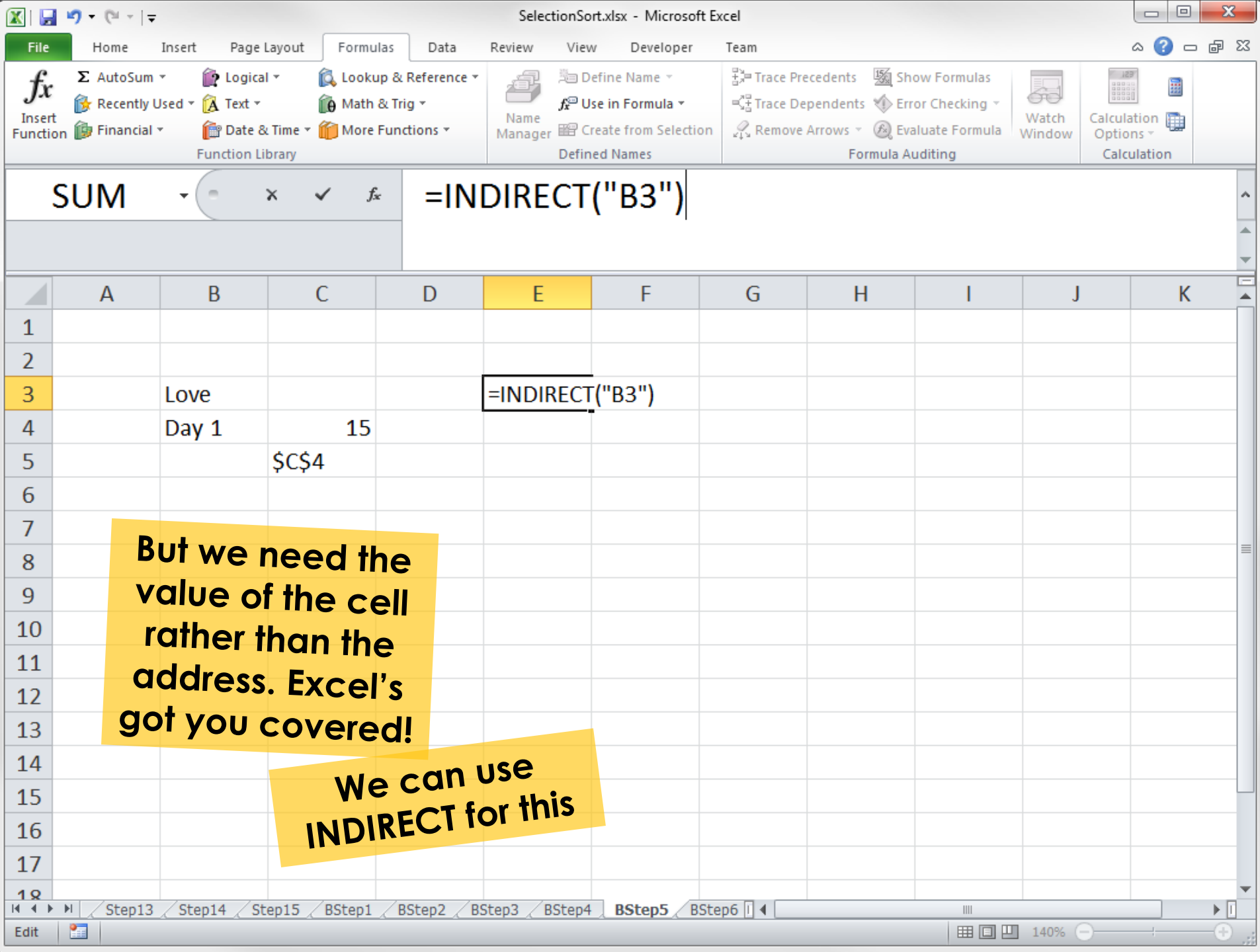
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Formula Auditing
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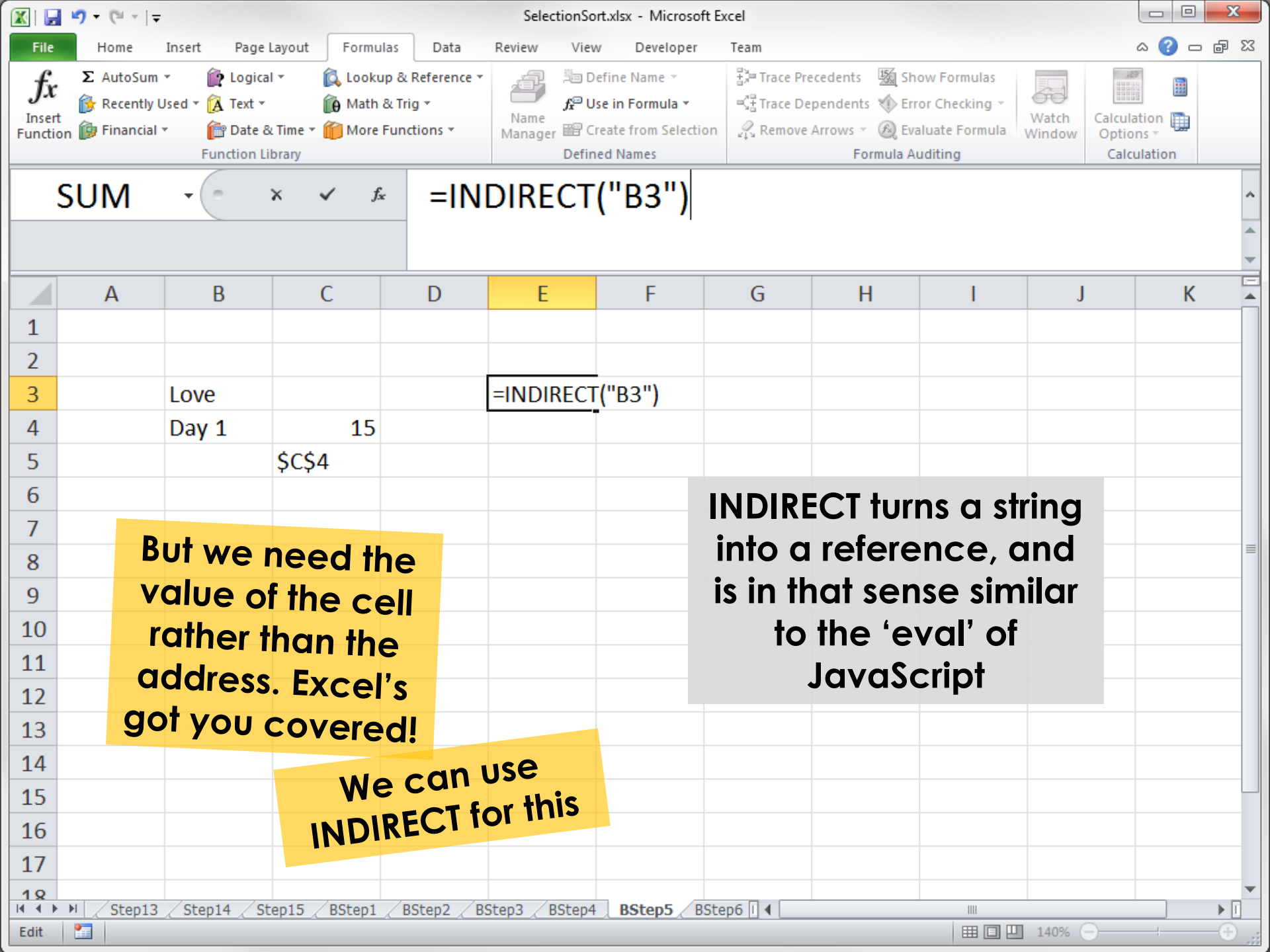
Calculation Options
Calculation
SUM
=INDIRECT("B3")
A B C D E F G H I J K
1
2
3 Love =INDIRECT("B3")
4 Day 1 15
5 $C$4
6
7
8
9
10
11
12
13
14
15
16
17
But we need the value of the cell rather than the address. Excel's got you covered!
We can use INDIRECT for this
Step13 Step14 Step15 BStep1 BStep2 BStep3 BStep4 BStep5 BStep6
Edit
140%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SUM
=INDIRECT("B3")
A B C D E F G H I J K
1
2
3 Love =INDIRECT("B3")
4 Day 1 15
5 $C$4
6
7
8
9
10
11
12
13
14
15
16
17
18
But we need the value of the cell rather than the address. Excel's got you covered!
We can use INDIRECT for this
INDIRECT turns a string into a reference, and is in that sense similar to the 'eval' of JavaScript
Step13
Step14
Step15
BStep1
BStep2
BStep3
BStep4
BStep5
BStep6
Edit
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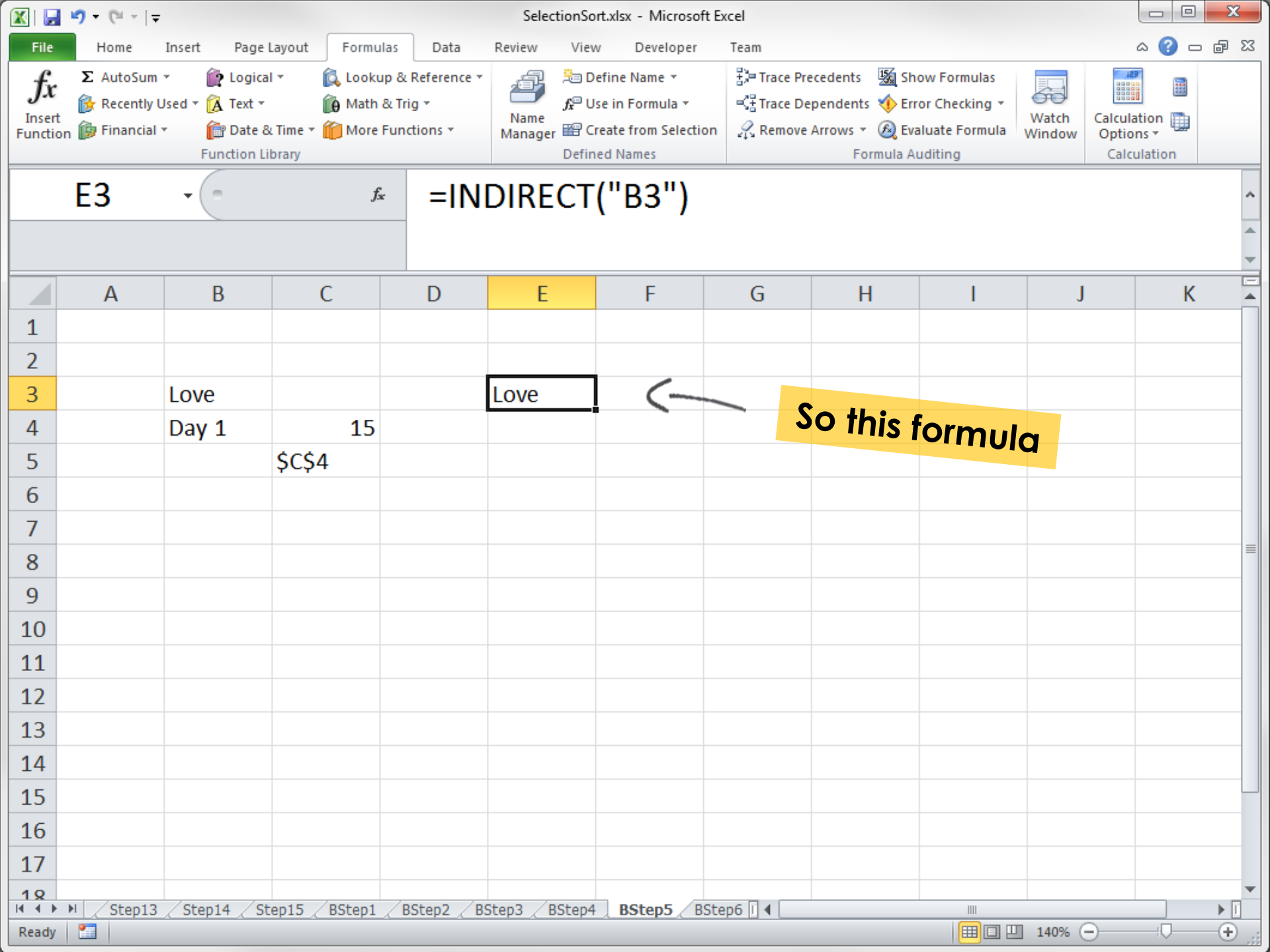
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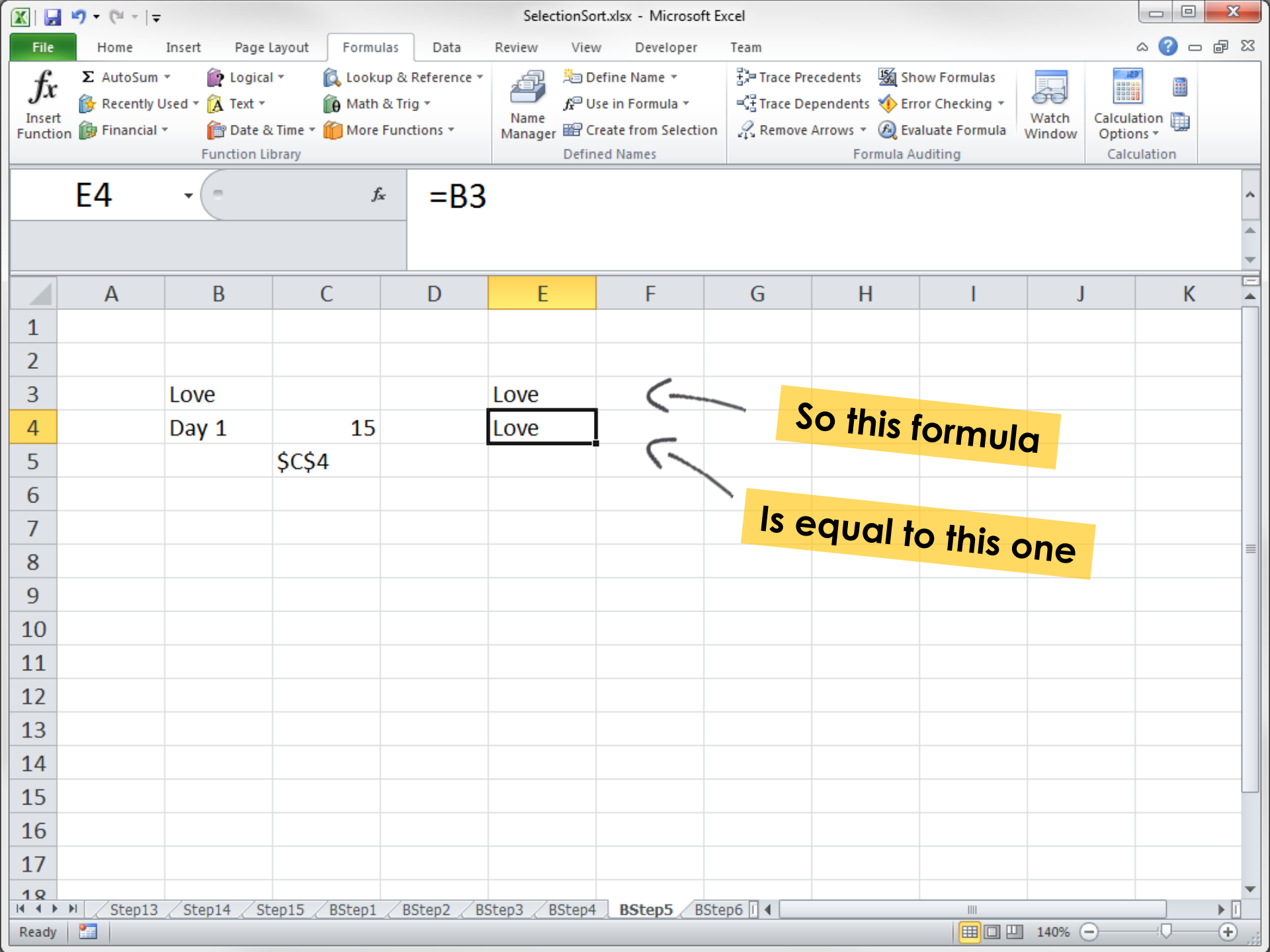
Error Checking
Evaluate Formula
Formula Auditing
Watch Window
Calculation Options
Calculation
E3
=INDIRECT("B3")
Love
Day 1
15
$C$4
Love
So this formula
Step13
Step14
Step15
BStep1
BStep2
BStep3
BStep4
BStep5
BStep6
Ready
140%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Calculation Options
Calculation
E4
=B3
A B C D E F G H I J K
1
2
3 Love Love
4 Day 1 15 Love
5 $C$4
6
7
8
9
10
11
12
13
14
15
16
17
18
So this formula
Is equal to this one
Step13 Step14 Step15 BStep1 BStep2 BStep3 BStep4 BStep5 BStep6
Ready
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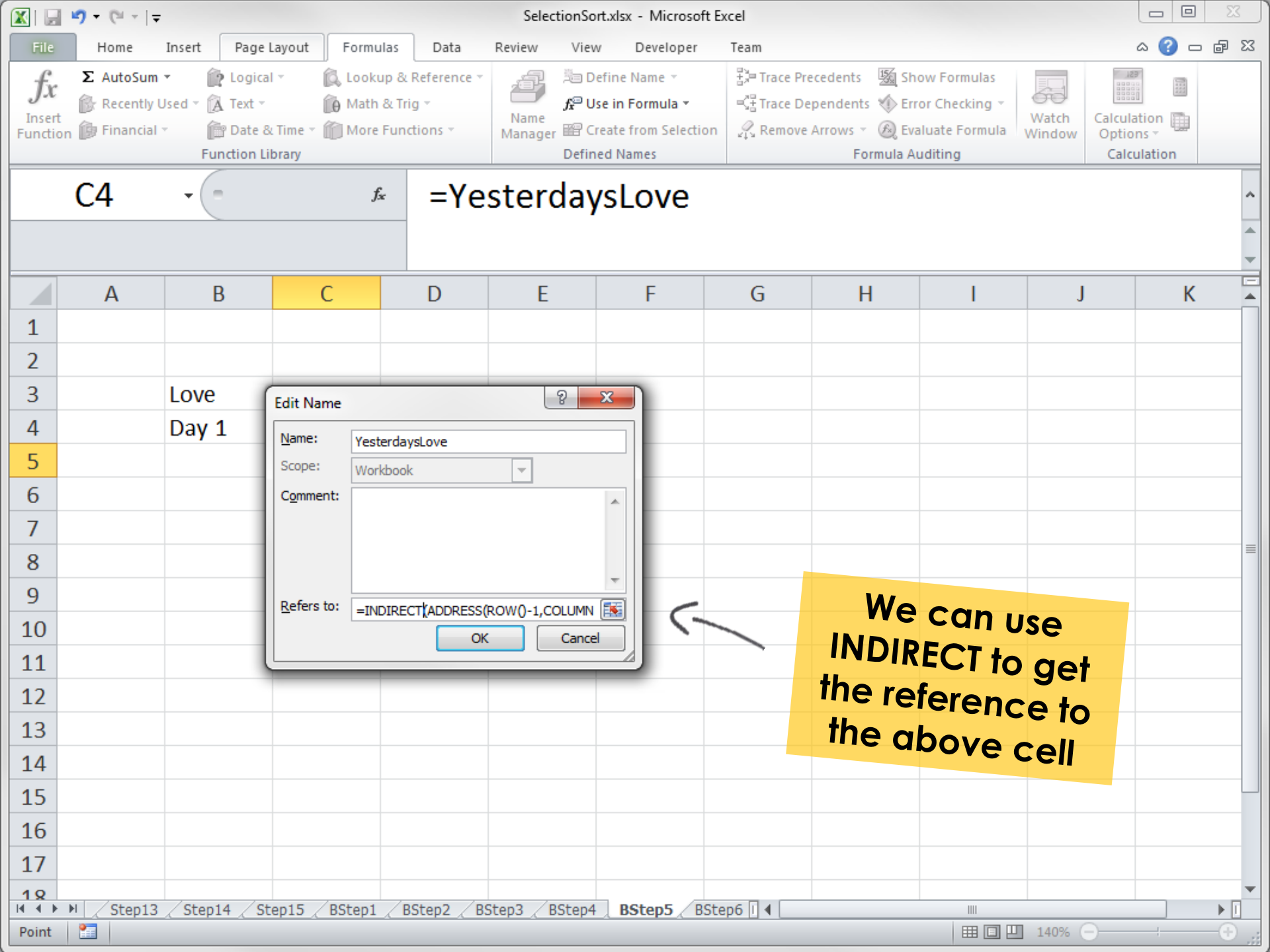
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Calculation Options
Calculation
C4
=YesterdaysLove
Love
Day 1
Edit Name
Name: YesterdaysLove
Scope: Workbook
Comment:
Refers to: =INDIRECT(ADDRESS(ROW()-1,COLUMN
OK
Cancel
We can use INDIRECT to get the reference to the above cell
Step13
Step14
Step15
BStep1
BStep2
BStep3
BStep4
BStep5
BStep6
Point
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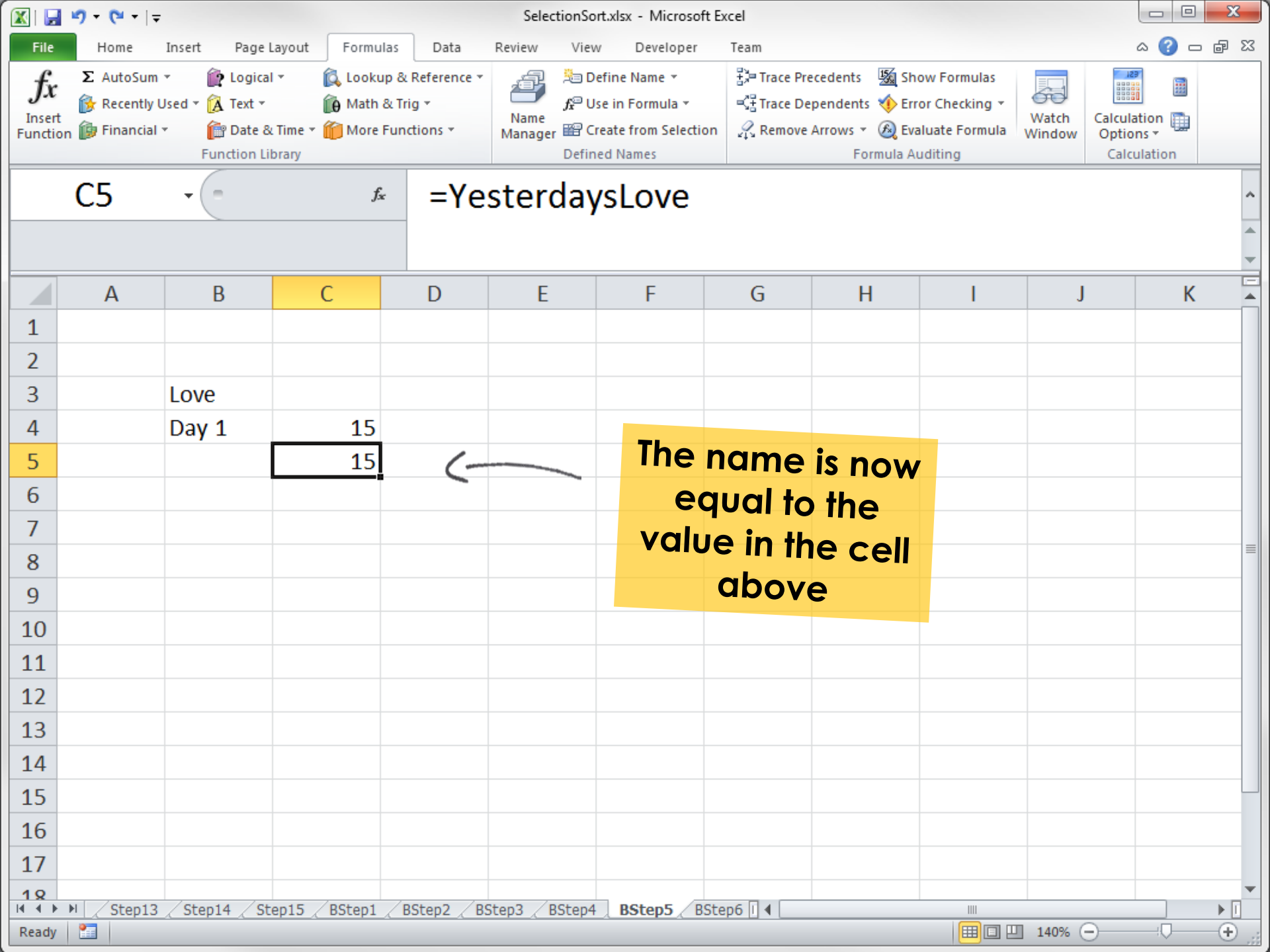
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Trace Precedents
Trace Dependents
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Evaluate Formula
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Calculation
C5
=YesterdaysLove
A B C D E F G H I J K
1
2
3 Love
4 Day 1 15
5 15
6
7
8
9
10
11
12
13
14
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16
17
18
The name is now equal to the value in the cell above
Step13 Step14 Step15 BStep1 BStep2 BStep3 BStep4 BStep5 BStep6
Ready
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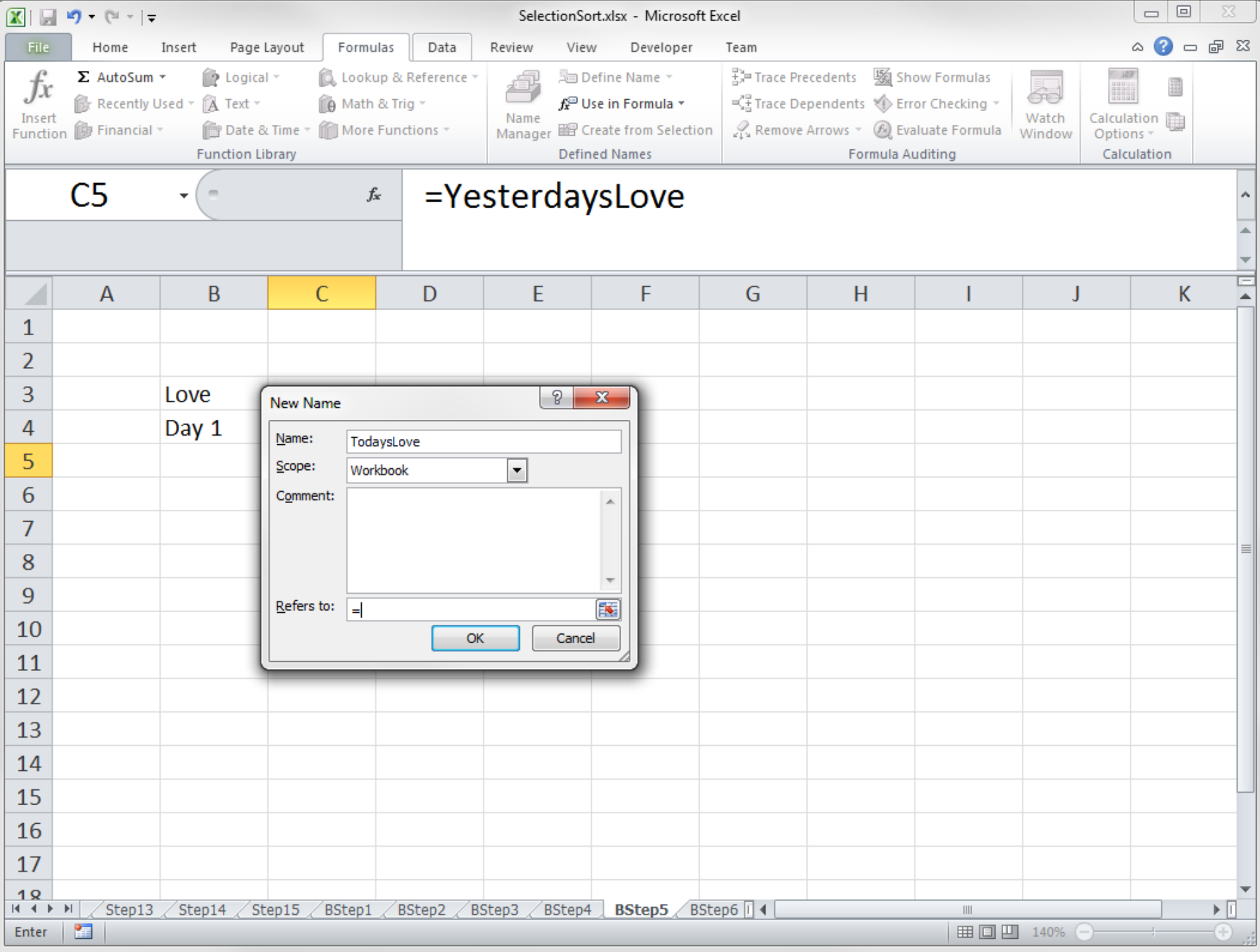
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C5
=YesterdaysLove
Love
Day 1
New Name
Name:
TodaysLove
Scope:
Workbook
Comment:
Refers to:
=
OK
Cancel
Step13
Step14
Step15
BStep1
BStep2
BStep3
BStep4
BStep5
BStep6
Enter
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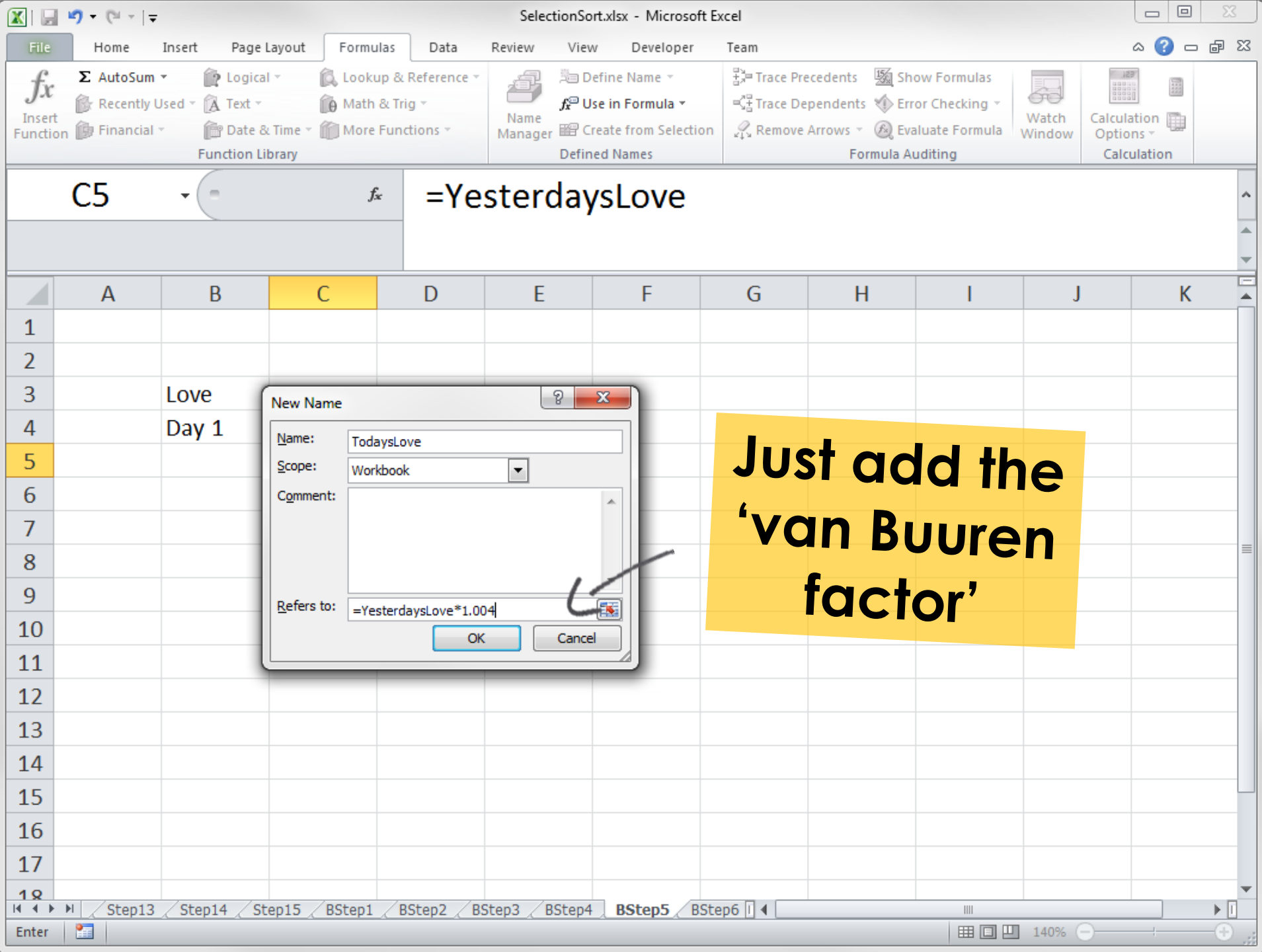
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Love
Day 1
New Name
Name:
TodaysLove
Scope:
Workbook
Comment:
Refers to:
=YesterdaysLove*1.004
OK
Cancel
Just add the 'van Buuren factor'
Step13
Step14
Step15
BStep1
BStep2
BStep3
BStep4
BStep5
BStep6
Enter
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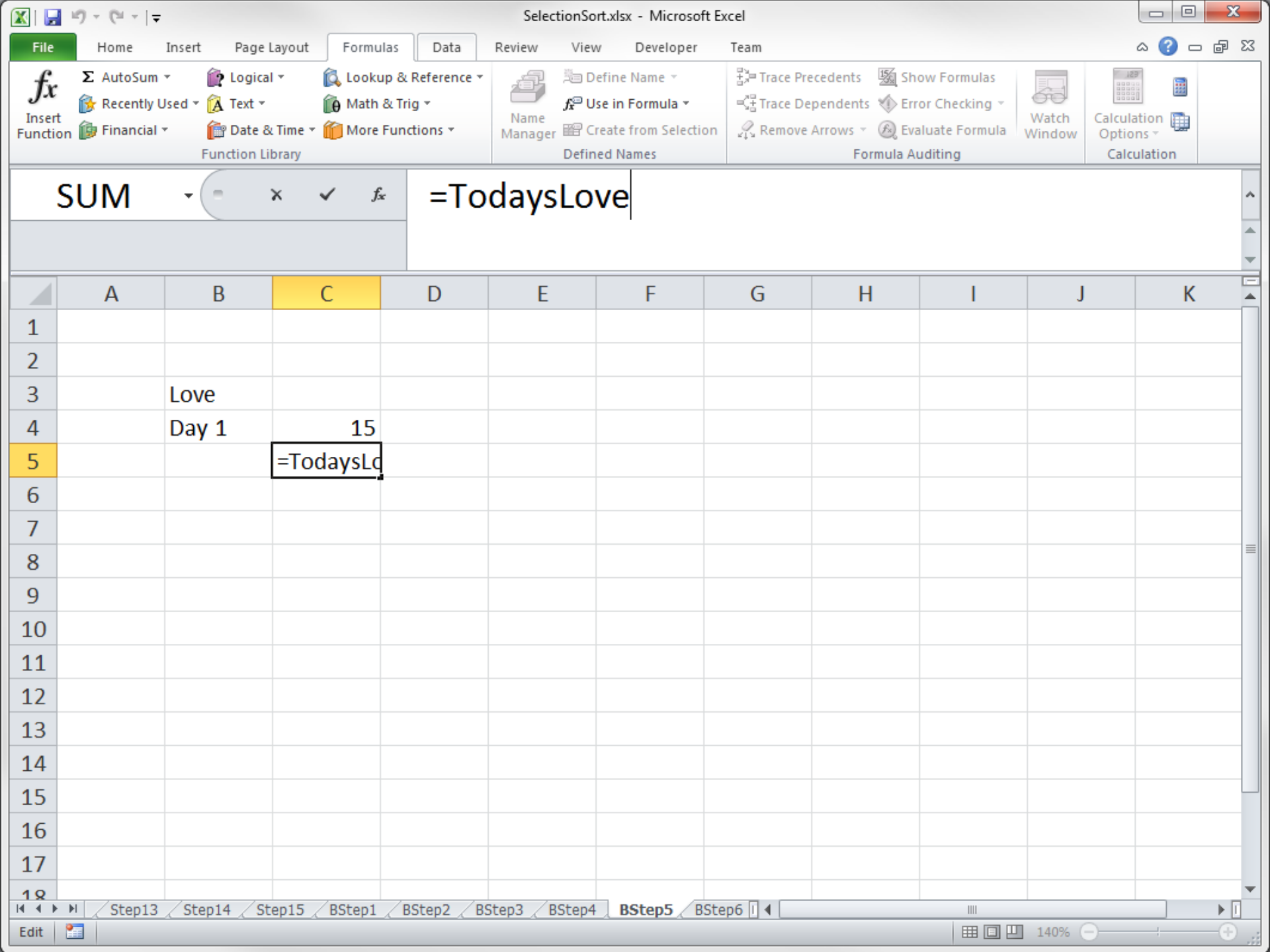
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Love
4
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Step14
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BStep2
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BStep5
BStep6
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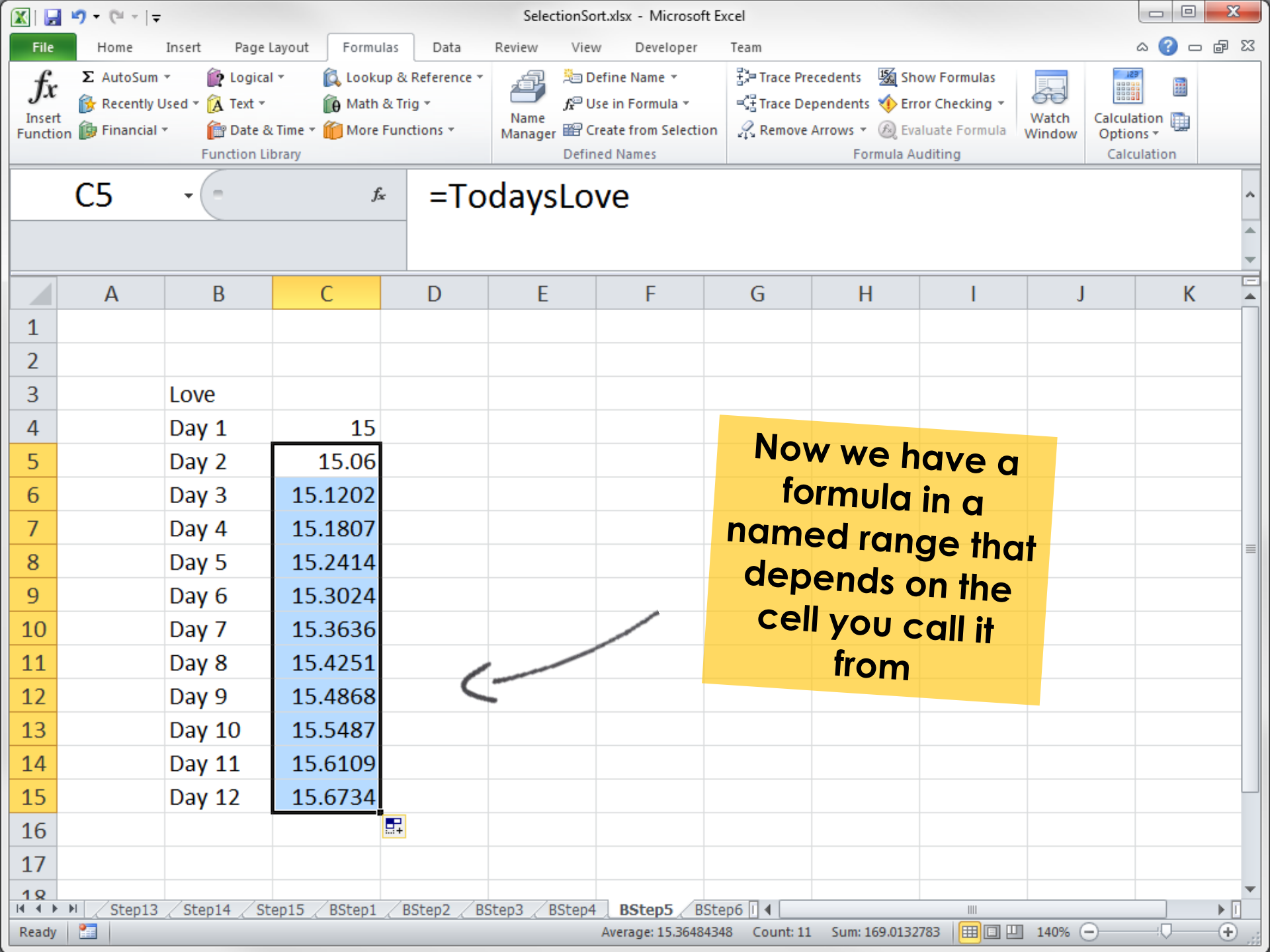
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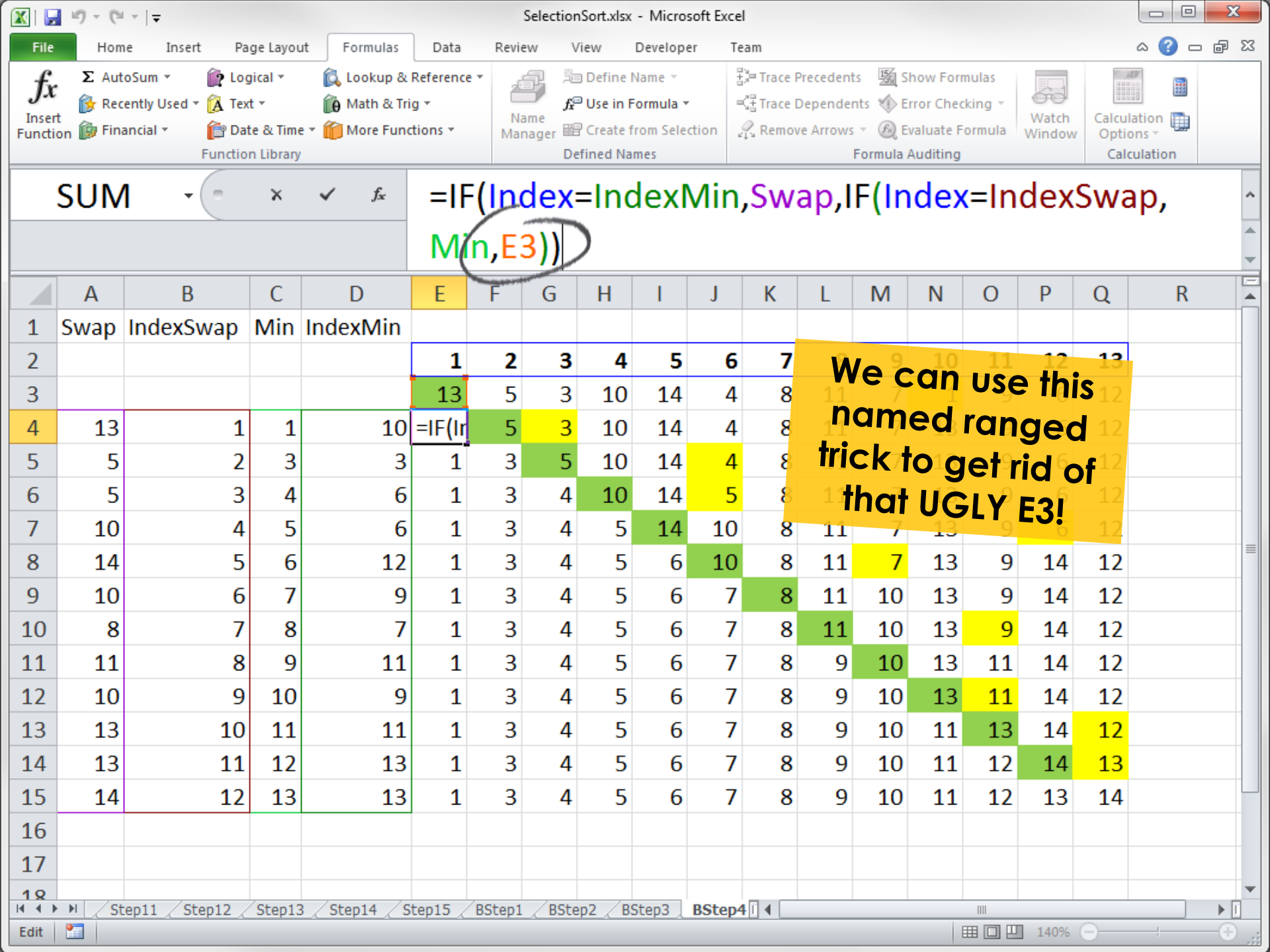
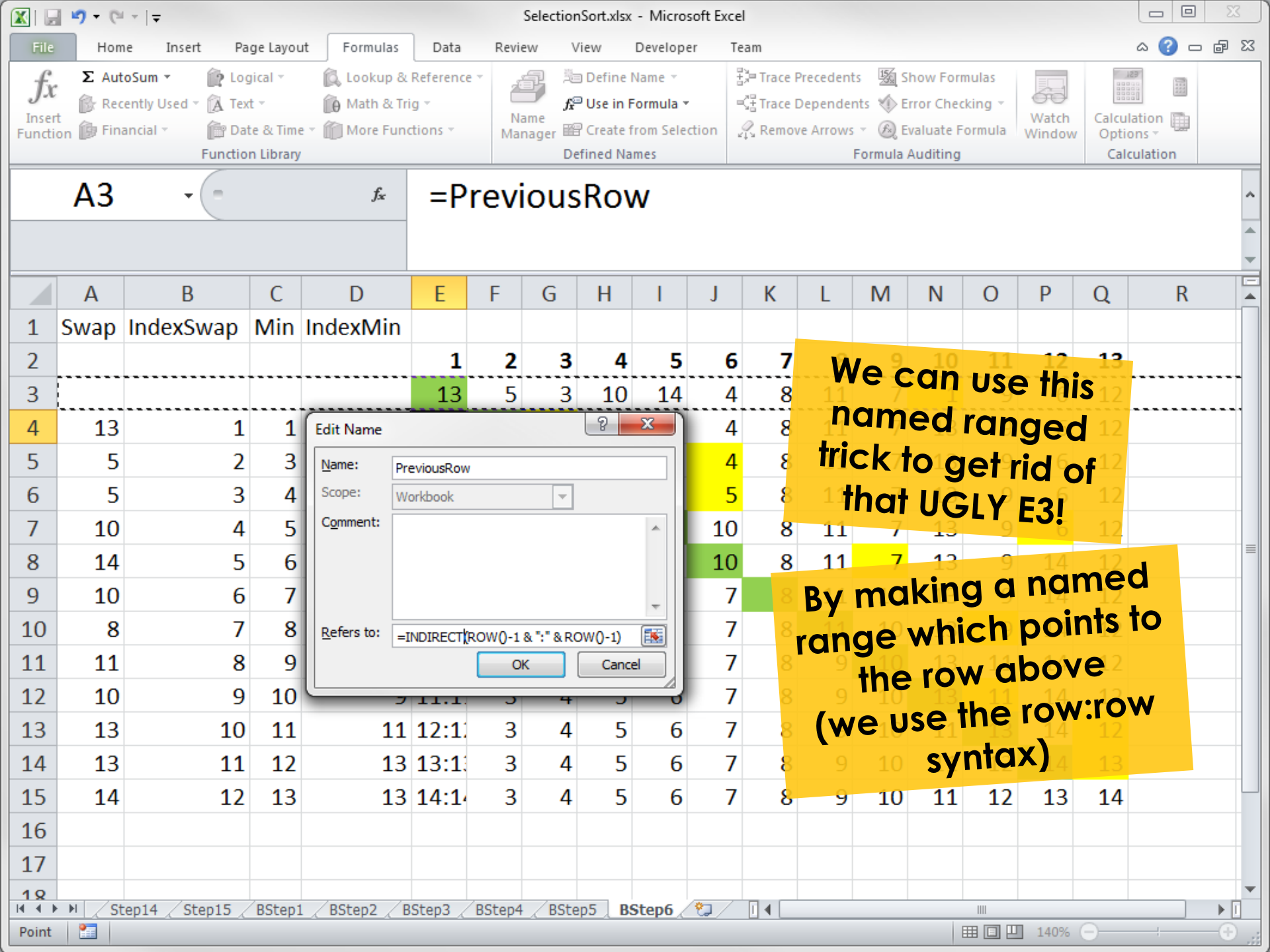
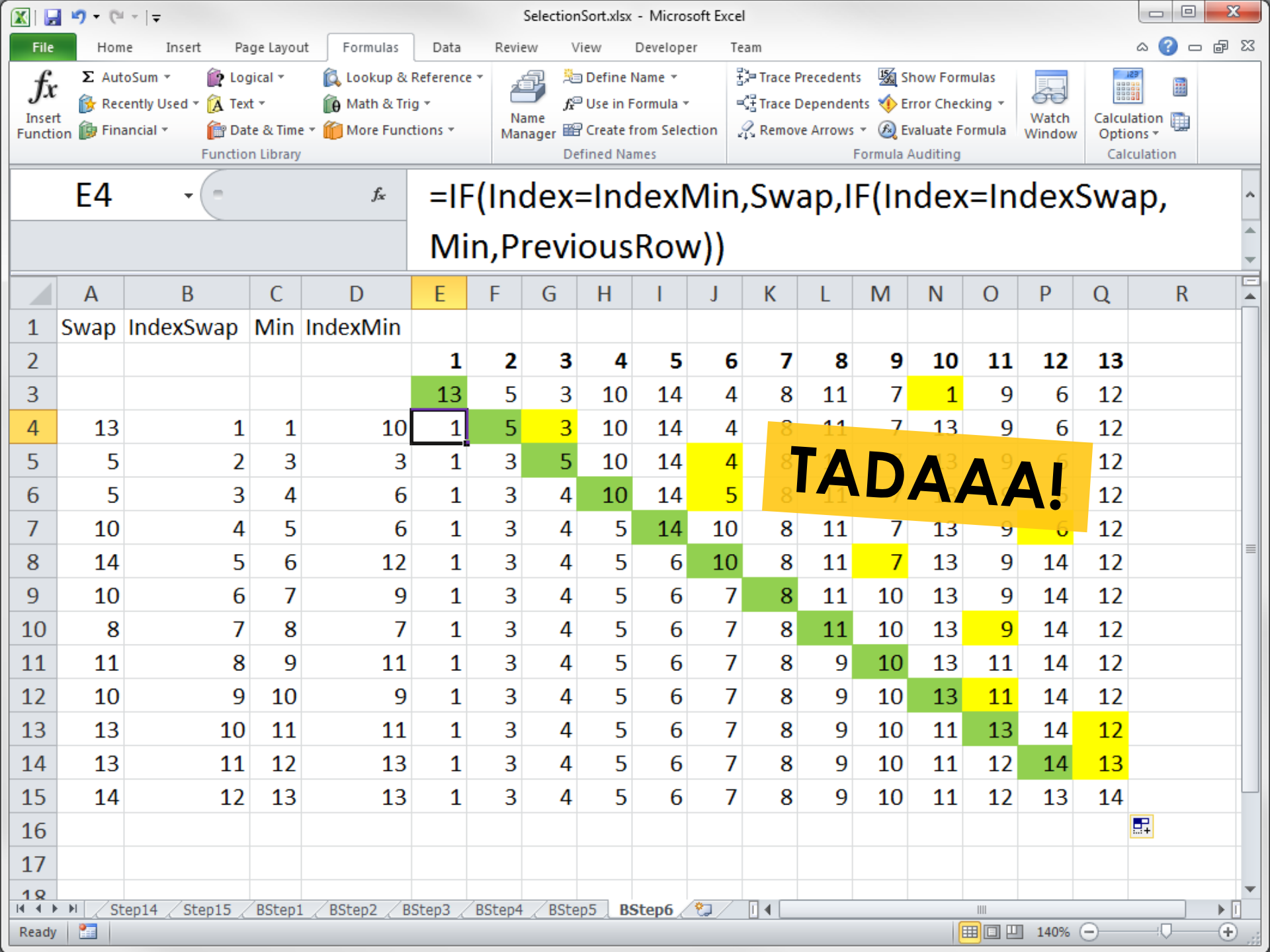
Trace Dependents
Remove Arrows
Show Formulas
Error Checking
Evaluate Formula
Formula Auditing
Watch Window
Calculation Options
Calculation
C5
=TodaysLove
Love
Day 1 15
Day 2 15.06
Day 3 15.1202
Day 4 15.1807
Day 5 15.2414
Day 6 15.3024
Day 7 15.3636
Day 8 15.4251
Day 9 15.4868
Day 10 15.5487
Day 11 15.6109
Day 12 15.6734
Now we have a formula in a named range that depends on the cell you call it from
Step13
Step14
Step15
BStep1
BStep2
BStep3
BStep4
BStep5
BStep6
Ready
Average: 15.36484348
Count: 11
Sum: 169.0132783
140%



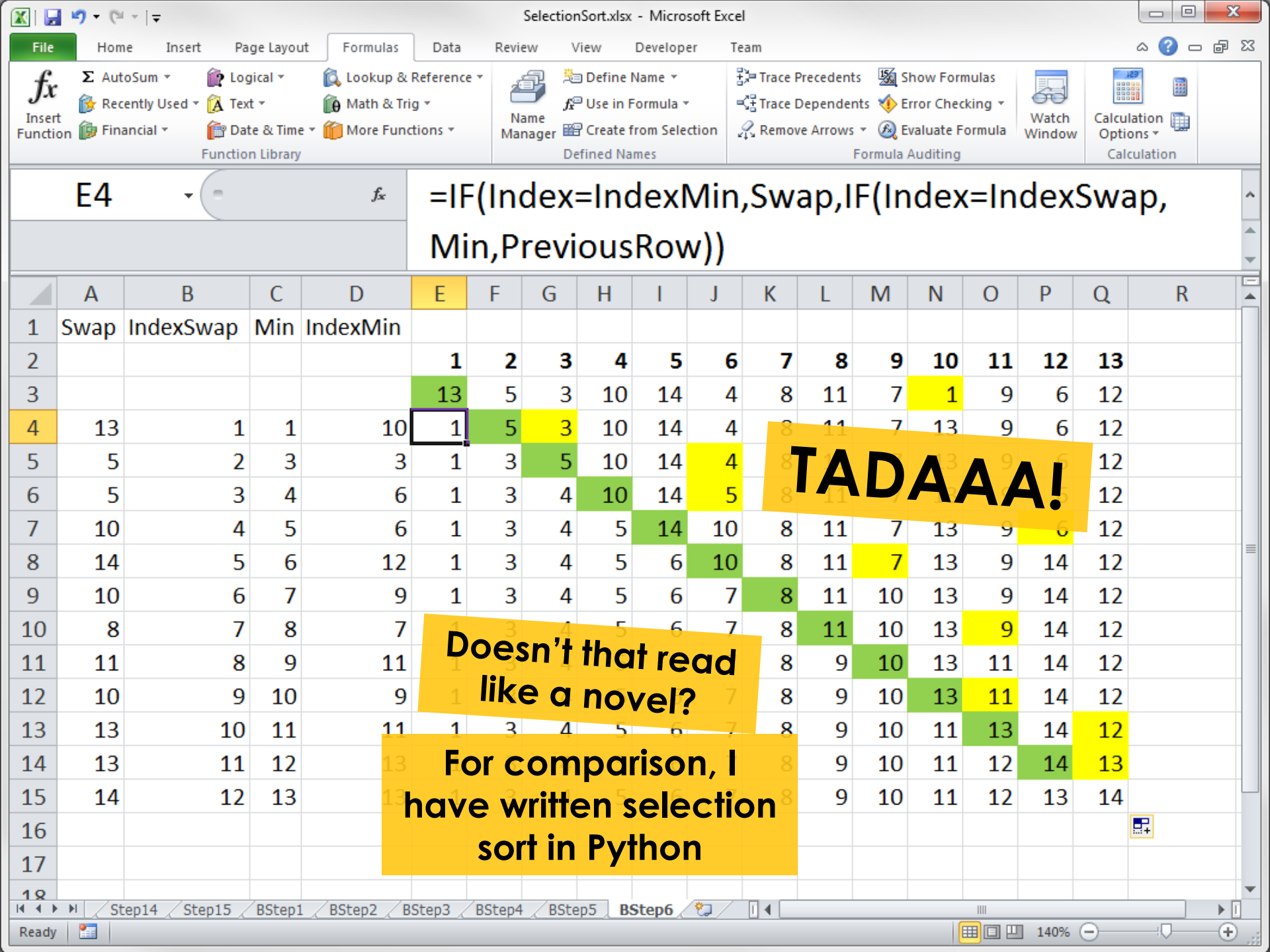
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
1	Swap	IndexSwap	Min	IndexMin														
2					1	2	3	4	5	6	7							
3					13	5	3	10	14	4	8							
4	13	1	1	10	=IF(In	5	3	10	14	4	8							
5	5	2	3	3	1	3	5	10	14	4	8							
6	5	3	4	6	1	3	4	10	14	5	8							
7	10	4	5	6	1	3	4	5	14	10	8	11	7	13	9	14	12	
8	14	5	6	12	1	3	4	5	6	10	8	11	7	13	9	14	12	
9	10	6	7	9	1	3	4	5	6	7	8	11	10	13	9	14	12	
10	8	7	8	7	1	3	4	5	6	7	8	11	10	13	9	14	12	
11	11	8	9	11	1	3	4	5	6	7	8	9	10	13	11	14	12	
12	10	9	10	9	1	3	4	5	6	7	8	9	10	13	11	14	12	
13	13	10	11	11	1	3	4	5	6	7	8	9	10	11	13	14	12	
14	13	11	12	13	1	3	4	5	6	7	8	9	10	11	12	14	13	
15	14	12	13	13	1	3	4	5	6	7	8	9	10	11	12	13	14	
16																		
17																		



	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
1	Swap	IndexSwap	Min	IndexMin														
2					1	2	3	4	5	6	7							
3					13	5	3	10	14	4	8							
4	13	1	1							4	8							
5	5	2	3							4	8							
6	5	3	4							5	8							
7	10	4	5							10	8	11						
8	14	5	6							10	8	11	7					
9	10	6	7							7								
10	8	7	8							7								
11	11	8	9							7								
12	10	9	10							7								
13	13	10	11	11	12:1	3	4	5	6	7								
14	13	11	12	13	13:1	3	4	5	6	7	8	9	10	11	12	13		
15	14	12	13	13	14:1	3	4	5	6	7	8	9	10	11	12	13	14	
16																		
17																		



	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
1	Swap	IndexSwap	Min	IndexMin														
2					**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	
3					13	5	3	10	14	4	8	11	7	1	9	6	12	
4	13	1	1	10	1	5	3	10	14	4	8	11	7	13	9	6	12	
5	5	2	3	3	1	3	5	10	14	4	8	11	7	13	9	6	12	
6	5	3	4	6	1	3	4	10	14	5	8	11	7	13	9	6	12	
7	10	4	5	6	1	3	4	5	14	10	8	11	7	13	9	6	12	
8	14	5	6	12	1	3	4	5	6	10	8	11	7	13	9	14	12	
9	10	6	7	9	1	3	4	5	6	7	8	11	10	13	9	14	12	
10	8	7	8	7	1	3	4	5	6	7	8	11	10	13	9	14	12	
11	11	8	9	11	1	3	4	5	6	7	8	9	10	13	11	14	12	
12	10	9	10	9	1	3	4	5	6	7	8	9	10	13	11	14	12	
13	13	10	11	11	1	3	4	5	6	7	8	9	10	11	13	14	12	
14	13	11	12	13	1	3	4	5	6	7	8	9	10	11	12	14	13	
15	14	12	13	13	1	3	4	5	6	7	8	9	10	11	12	13	14	
16																		
17																		
18																		



	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
1	Swap	IndexSwap	Min	IndexMin														
2					**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	
3					13	5	3	10	14	4	8	11	7	1	9	6	12	
4	13	1	1	10	1	5	3	10	14	4	8	11	7	13	9	6	12	
5	5	2	3	3	1	3	5	10	14	4	8	11	7	13	9	6	12	
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12	10	9	10	9	1	3	4	5	6	7	8	9	10	13	11	14	12	
13	13	10	11	11	1	3	4	5	6	7	8	9	10	11	13	14	12	
14	13	11	12	13	1	3	4	5	6	7	8	9	10	11	12	14	13	
15	14	12	13	12	1	3	4	5	6	7	8	9	10	11	12	13	14	
16																		
17																		

SelectionSort.py - C:/Users/Felienne/Dropbox/TU Delft/slides/2014/StrangeLoo...

File Edit Format Options Windows Help

```
def selectionSort(List):
    for IndexSwap in range(len(List)):

        Min = min(List[IndexSwap:])
        IndexMin = List.index(Min)

        Swap = List[IndexSwap]

        for Index in range(IndexSwap,len(List)):

            if Index == IndexMin:
                List[Index] = Swap

            elif Index == IndexSwap:
                List[Index] = Min

    return List
```

Similar, but a lot less concise! :)

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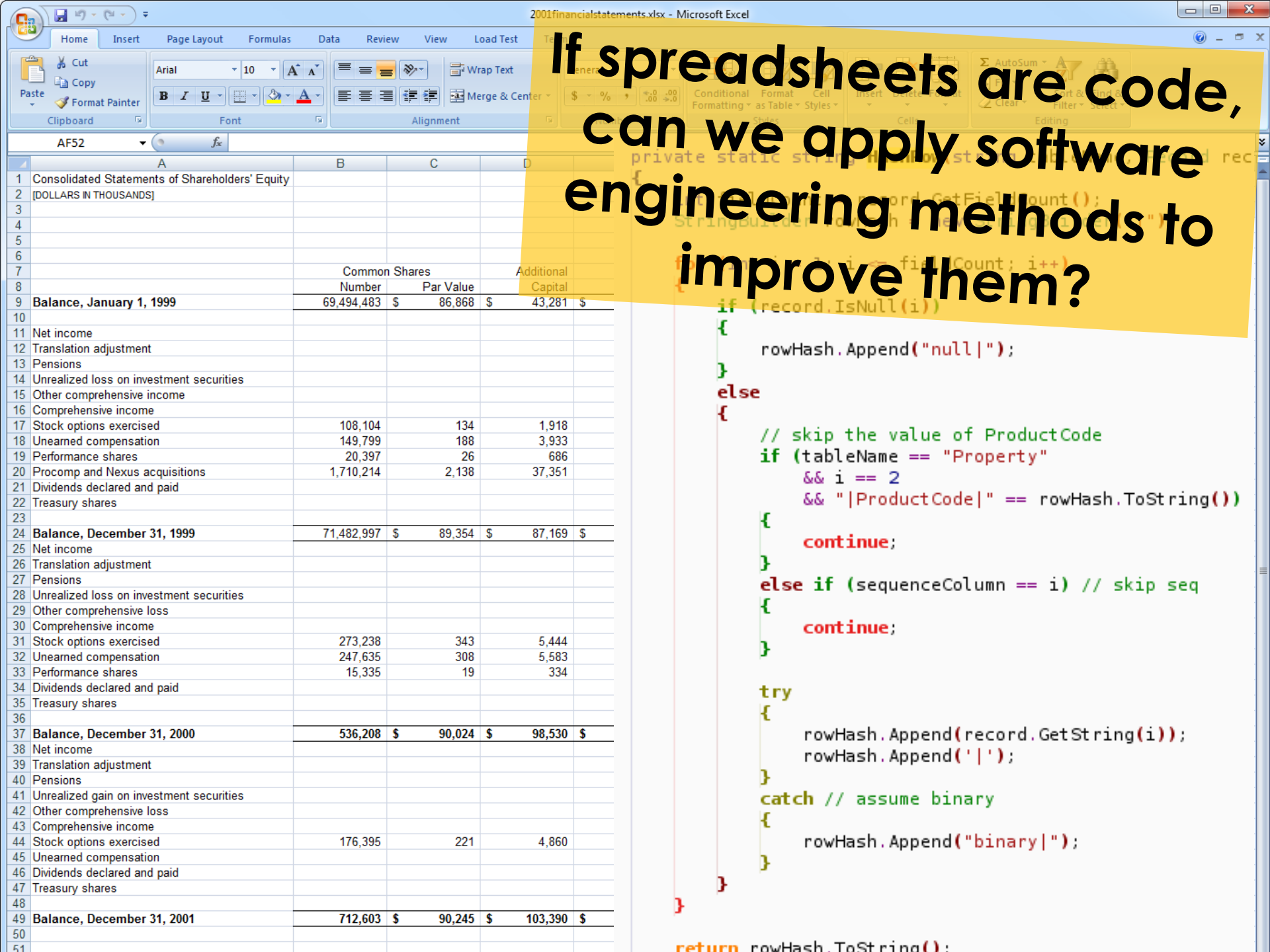
If spreadsheets are code, can we apply software engineering methods to improve them?



2001financialstatements.xlsx - Microsoft Excel

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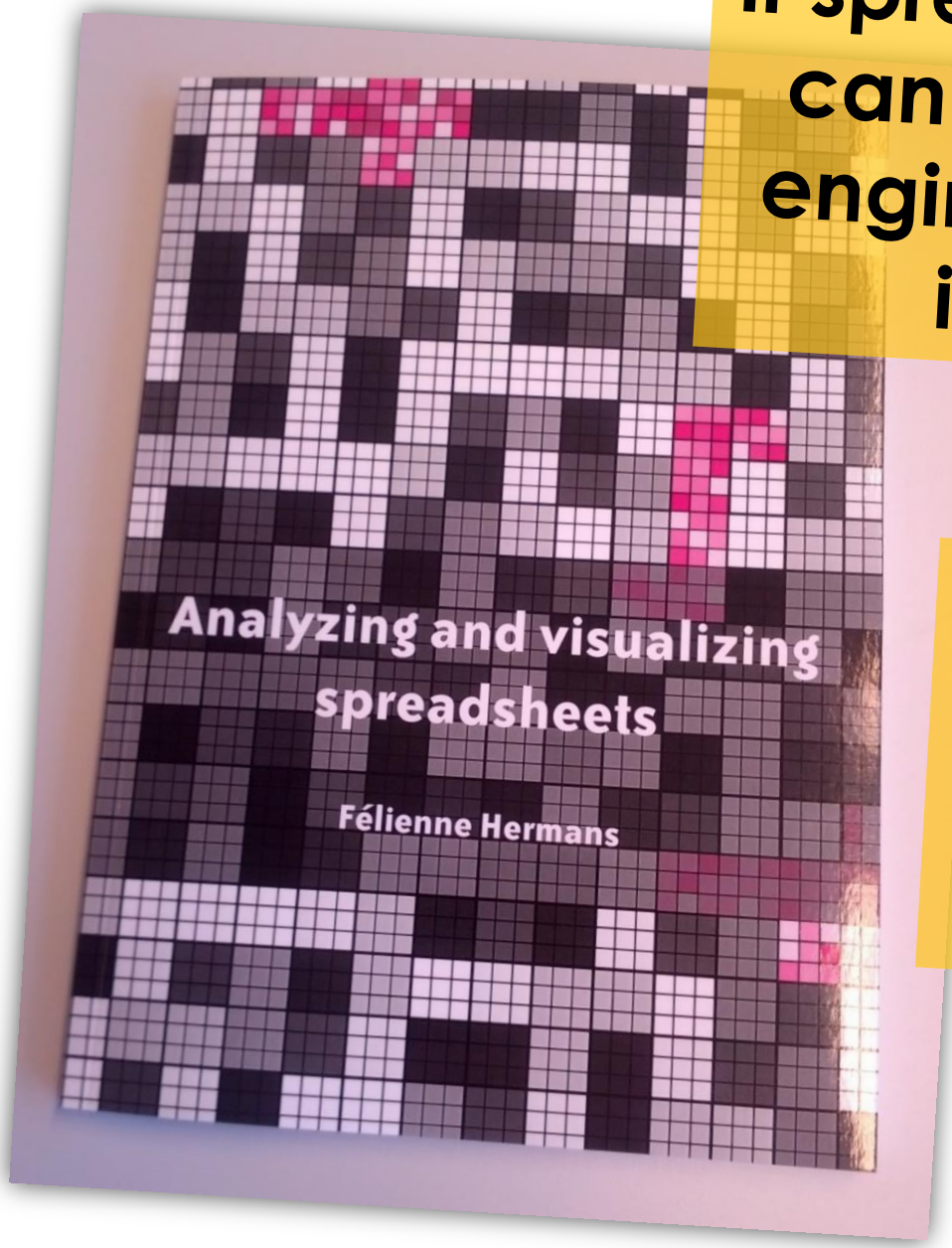
AF52

	A	B	C	D	
1	Consolidated Statements of Shareholders' Equity				
2	[DOLLARS IN THOUSANDS]				
3					
4					
5					
6					
7		Common Shares		Additional	
8		Number	Par Value	Capital	
9	**Balance, January 1, 1999**	69,494,483	$ 86,868	$ 43,281	$
10					
11	Net income				
12	Translation adjustment				
13	Pensions				
14	Unrealized loss on investment securities				
15	Other comprehensive income				
16	Comprehensive income				
17	Stock options exercised	108,104	134	1,918	
18	Unearned compensation	149,799	188	3,933	
19	Performance shares	20,397	26	686	
20	Procomp and Nexus acquisitions	1,710,214	2,138	37,351	
21	Dividends declared and paid				
22	Treasury shares				
23					
24	**Balance, December 31, 1999**	71,482,997	$ 89,354	$ 87,169	$
25	Net income				
26	Translation adjustment				
27	Pensions				
28	Unrealized loss on investment securities				
29	Other comprehensive loss				
30	Comprehensive income				
31	Stock options exercised	273,238	343	5,444	
32	Unearned compensation	247,635	308	5,583	
33	Performance shares	15,335	19	334	
34	Dividends declared and paid				
35	Treasury shares				
36					
37	**Balance, December 31, 2000**	**536,208**	**$ 90,024**	**$ 98,530**	**$**
38	Net income				
39	Translation adjustment				
40	Pensions				
41	Unrealized gain on investment securities				
42	Other comprehensive loss				
43	Comprehensive income				
44	Stock options exercised	176,395	221	4,860	
45	Unearned compensation				
46	Dividends declared and paid				
47	Treasury shares				
48					
49	**Balance, December 31, 2001**	**712,603**	**$ 90,245**	**$ 103,390**	**$**
50					

```
        if (record.IsNull(i))
        {
            rowHash.Append("null|");
        }
        else
        {
            // skip the value of ProductCode
            if (tableName == "Property"
                && i == 2
                && "|ProductCode|" == rowHash.ToString())
            {
                continue;
            }
            else if (sequenceColumn == i) // skip seq
            {
                continue;
            }

            try
            {
                rowHash.Append(record.GetString(i));
                rowHash.Append('|');
            }
            catch // assume binary
            {
                rowHash.Append("binary|");
            }
        }
    }

    return rowHash.ToString();
```

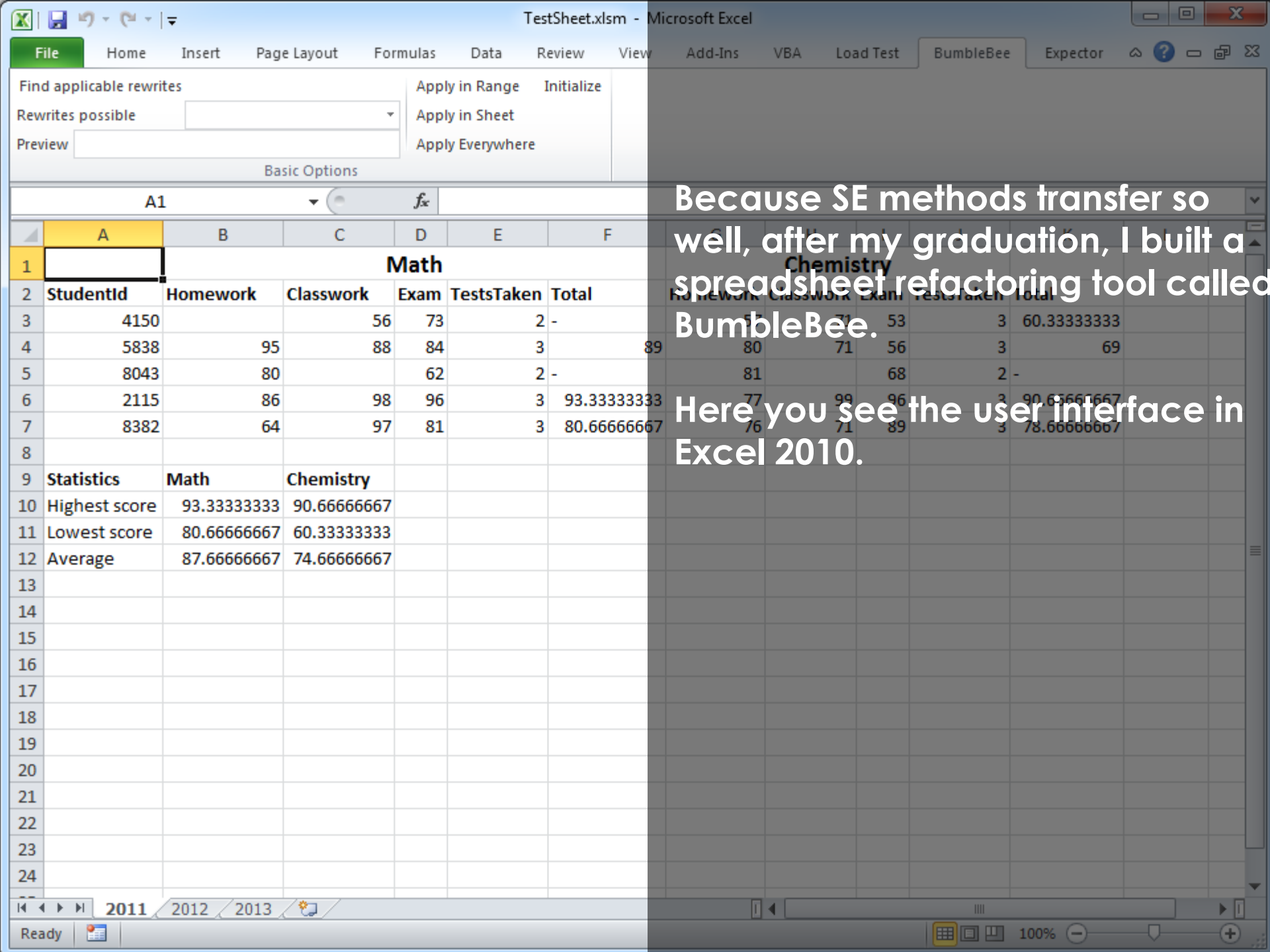


If spreadsheets are code, can we apply software engineering methods to improve them?

That is the central research question of my dissertation


The conclusion is:
YES WE CAN.
More info:
felienne.com/archives/2534

Because SE methods transfer so well, after my graduation, I built a spreadsheet refactoring tool called BumbleBee.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Apply in Sheet
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StudentId
Homework
Classwork
Exam
TestsTaken
Total
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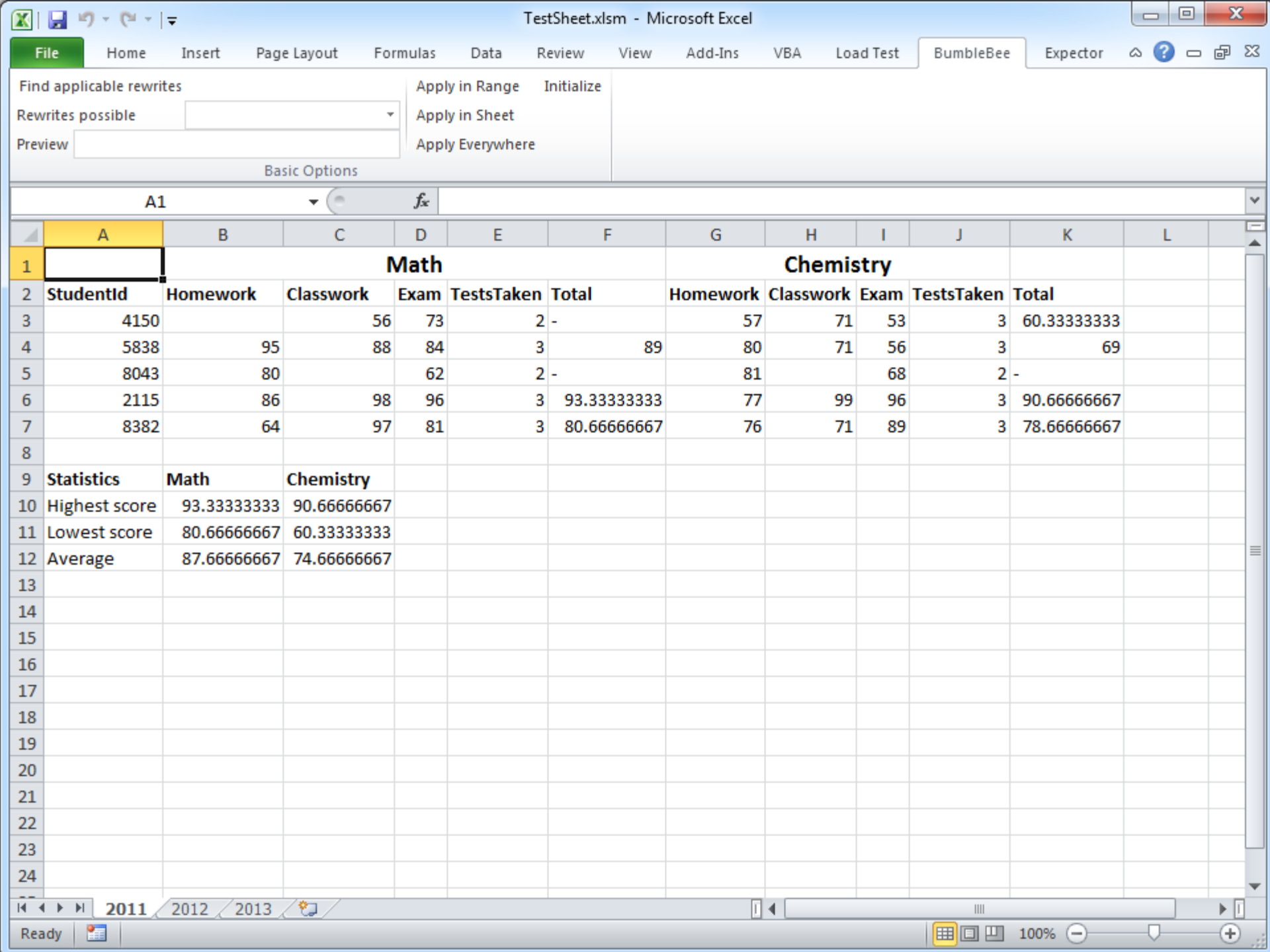
5838
8043
2115
8382
Statistics
Math
Chemistry
Highest score
93.33333333
90.66666667
Lowest score
80.66666667
60.33333333
Average
87.66666667
74.66666667
2011
2012
2013
Ready
100%
Because SE methods transfer so well, after my graduation, I built a spreadsheet refactoring tool called BumbleBee.
Here you see the user interface in Excel 2010.



	A	B	C	D	E	F	G	H	I	J	K	L
1		Math					Chemistry					
2	StudentId	Homework	Classwork	Exam	TestsTaken	Total	Homework	Classwork	Exam	TestsTaken	Total	
3	4150		56	73	2	-	57	71	53	3	60.33333333	
4	5838	95	88	84	3	89	80	71	56	3	69	
5	8043	80		62	2	-	81		68	2	-	
6	2115	86	98	96	3	93.33333333	77	99	96	3	90.66666667	
7	8382	64	97	81	3	80.66666667	76	71	89	3	78.66666667	
8												
9	Statistics	Math	Chemistry									
10	Highest score	93.33333333	90.66666667									
11	Lowest score	80.66666667	60.33333333									
12	Average	87.66666667	74.66666667									
13												
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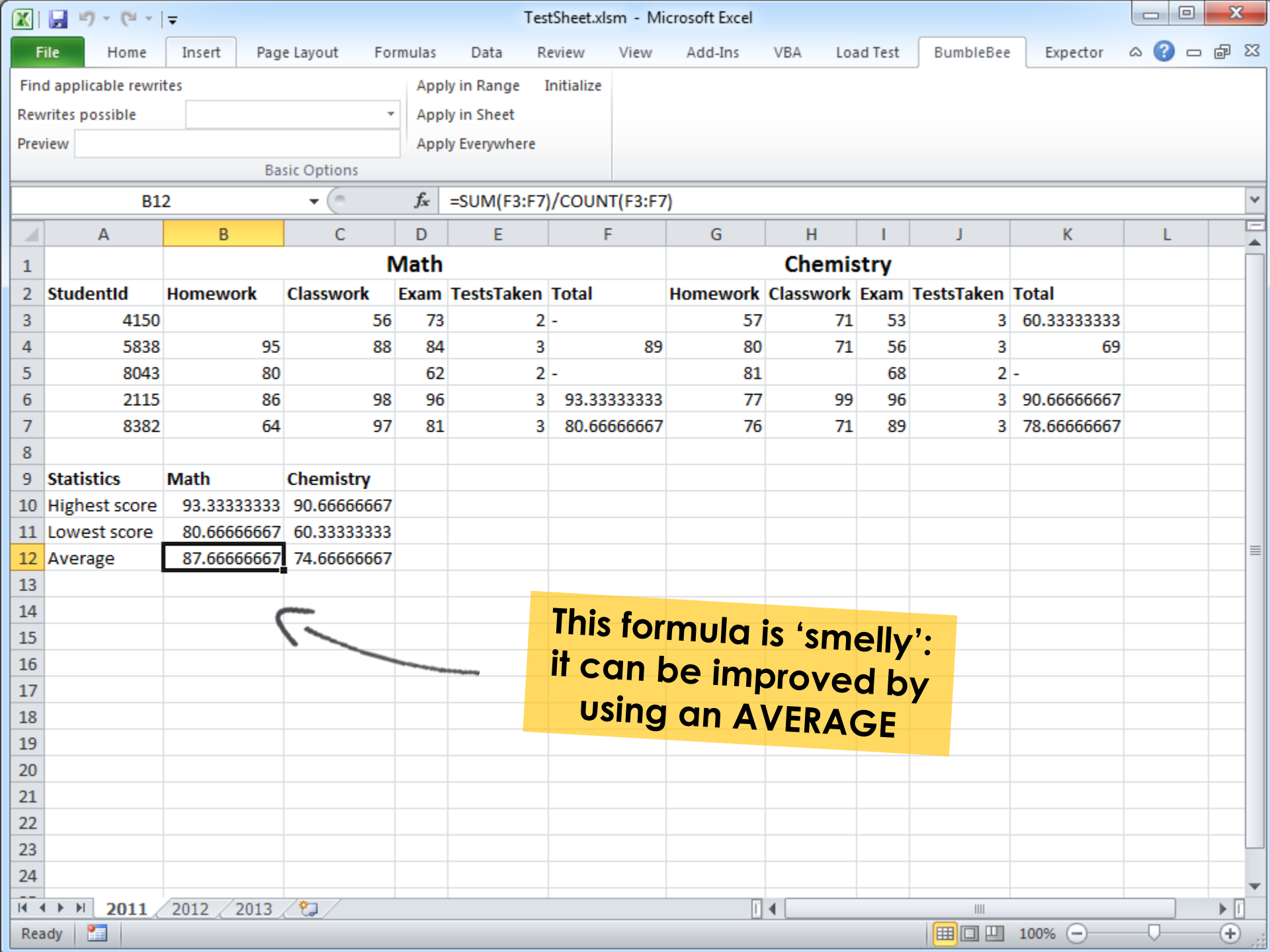
22												
23												
24												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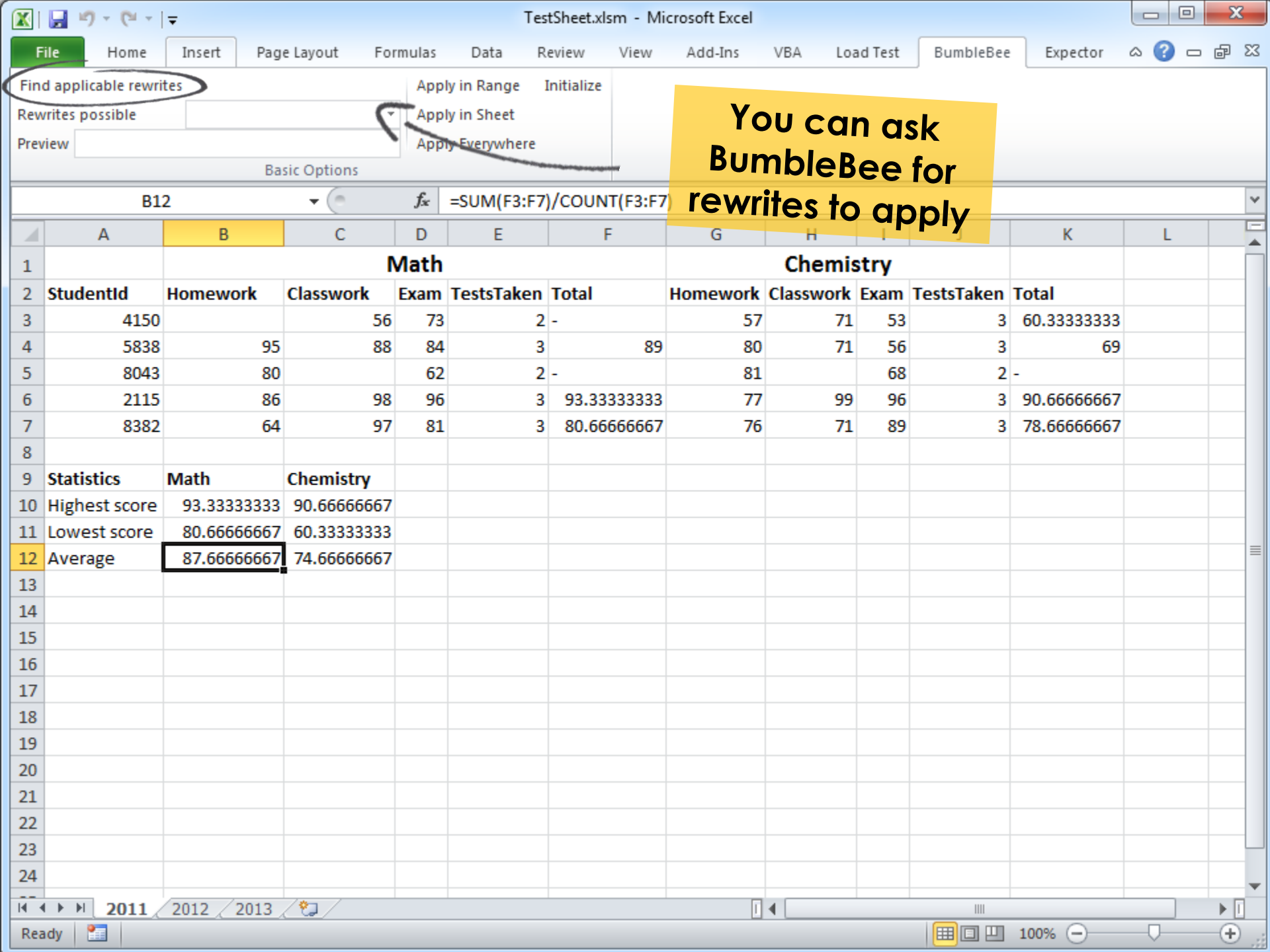
Load Test
BumbleBee
Expector
Find applicable rewrites
Rewrites possible
Preview
Basic Options
Apply in Range
Initialize
Apply in Sheet
Apply Everywhere
B12
=SUM(F3:F7)/COUNT(F3:F7)
Math
Chemistry
StudentId
Homework
Classwork
Exam
TestsTaken
Total
4150 56 73 2 - 57 71 53 3 60.33333333
5838 95 88 84 3 89 80 71 56 3 69
8043 80 62 2 - 81 68 2 -
2115 86 98 96 3 93.33333333 77 99 96 3 90.66666667
8382 64 97 81 3 80.66666667 76 71 89 3 78.66666667
Statistics
Math
Chemistry
Highest score 93.33333333 90.66666667
Lowest score 80.66666667 60.33333333
Average 87.66666667 74.66666667
This formula is 'smelly': it can be improved by using an AVERAGE
2011
2012
2013
Ready
100%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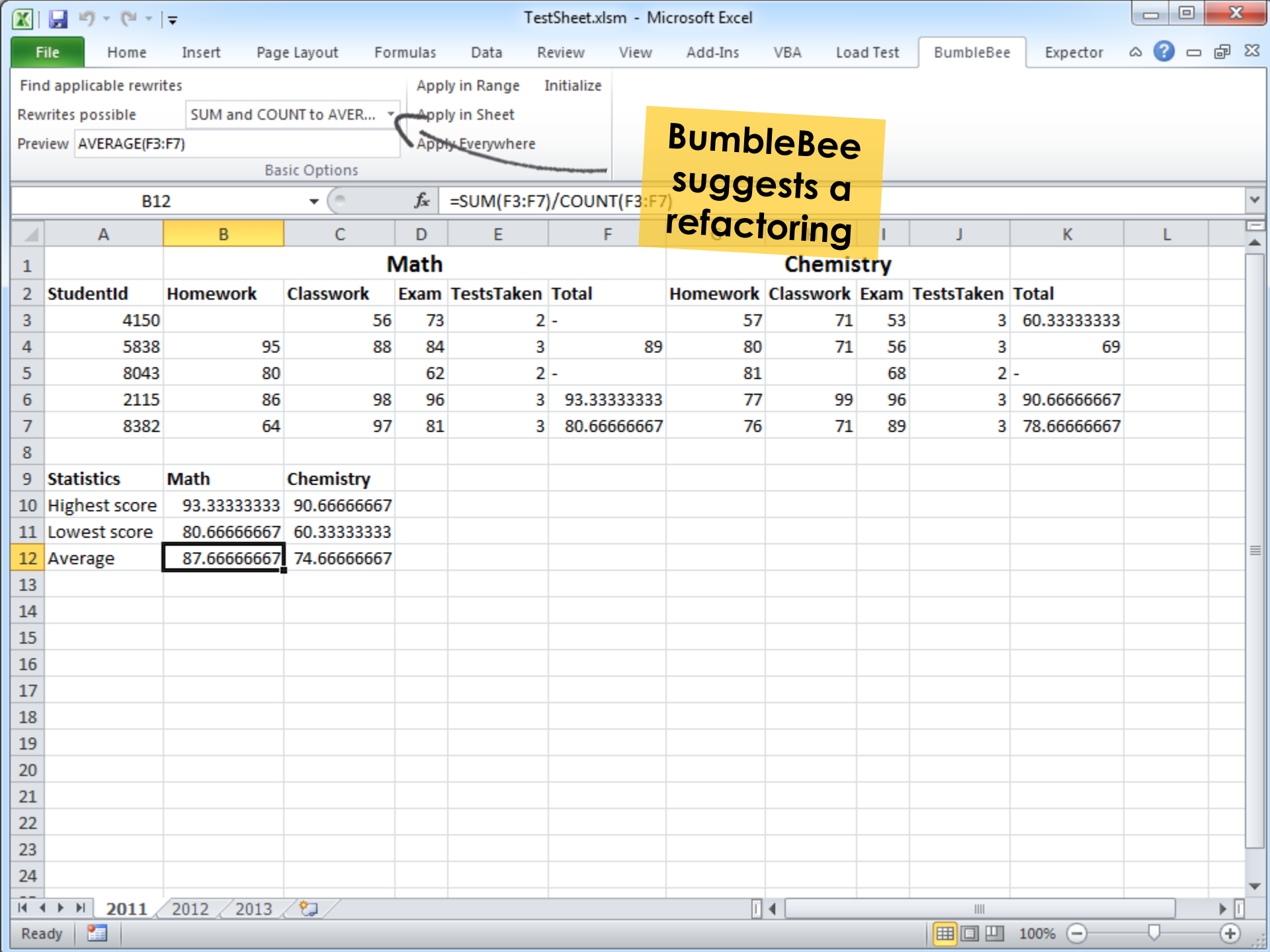
BumbleBee
Expector
Find applicable rewrites
Rewrites possible
Preview
Basic Options
Apply in Range
Initialize
Apply in Sheet
Apply Everywhere
You can ask BumbleBee for rewrites to apply
B12
=SUM(F3:F7)/COUNT(F3:F7)
Math
Chemistry
StudentId
Homework
Classwork
Exam
TestsTaken
Total
4150 56 73 2 - 57 71 53 3 60.33333333
5838 95 88 84 3 89 80 71 56 3 69
8043 80 62 2 - 81 68 2 -
2115 86 98 96 3 93.33333333 77 99 96 3 90.66666667
8382 64 97 81 3 80.66666667 76 71 89 3 78.66666667
Statistics
Math
Chemistry
Highest score 93.33333333 90.66666667
Lowest score 80.66666667 60.33333333
Average 87.66666667 74.66666667
2011
2012
2013
Ready
100%


TestSheet.xlsm - Microsoft Excel
File
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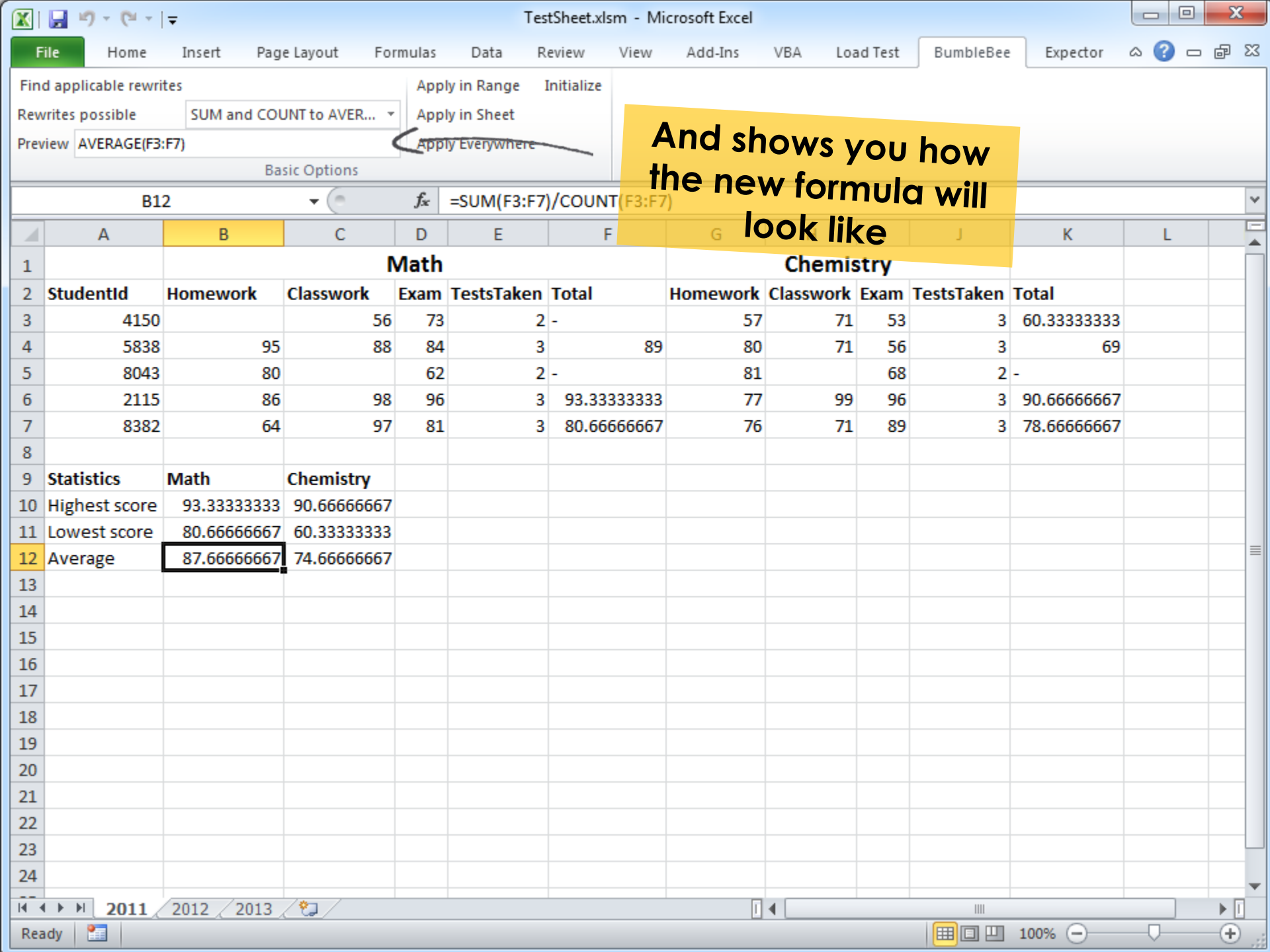
Load Test
BumbleBee
Expector
Find applicable rewrites
Rewrites possible
SUM and COUNT to AVER...
Preview
AVERAGE(F3:F7)
Basic Options
Apply in Range
Initialize
Apply in Sheet
Apply Everywhere
BumbleBee suggests a refactoring
B12
=SUM(F3:F7)/COUNT(F3:F7)
Math
Chemistry
StudentId
Homework
Classwork
Exam
TestsTaken
Total
4150
5838
8043
2115
8382
Statistics
Math
Chemistry
Highest score
93.33333333
90.66666667
Lowest score
80.66666667
60.33333333
Average
87.66666667
74.66666667
2011
2012
2013
Ready
100%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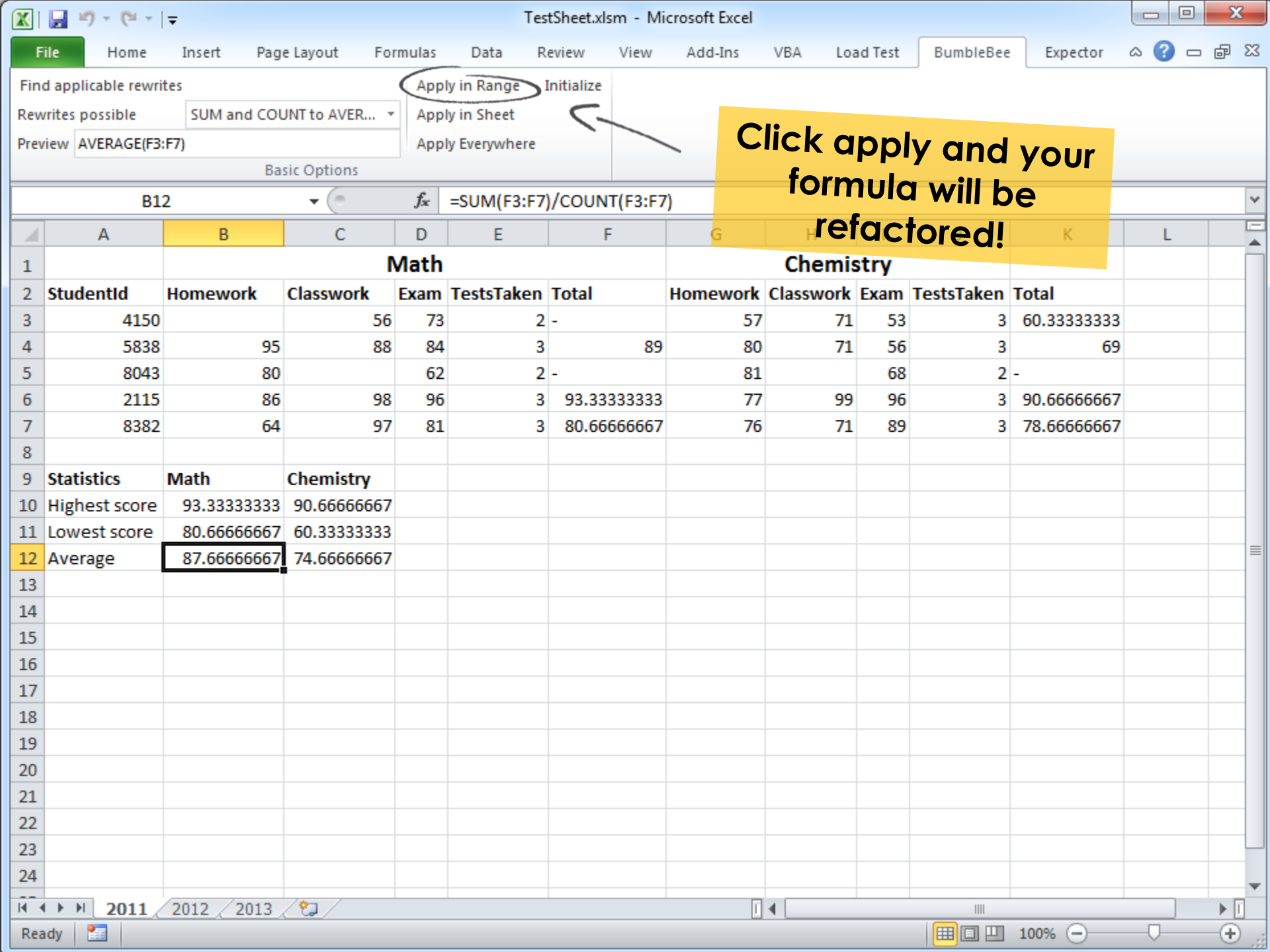
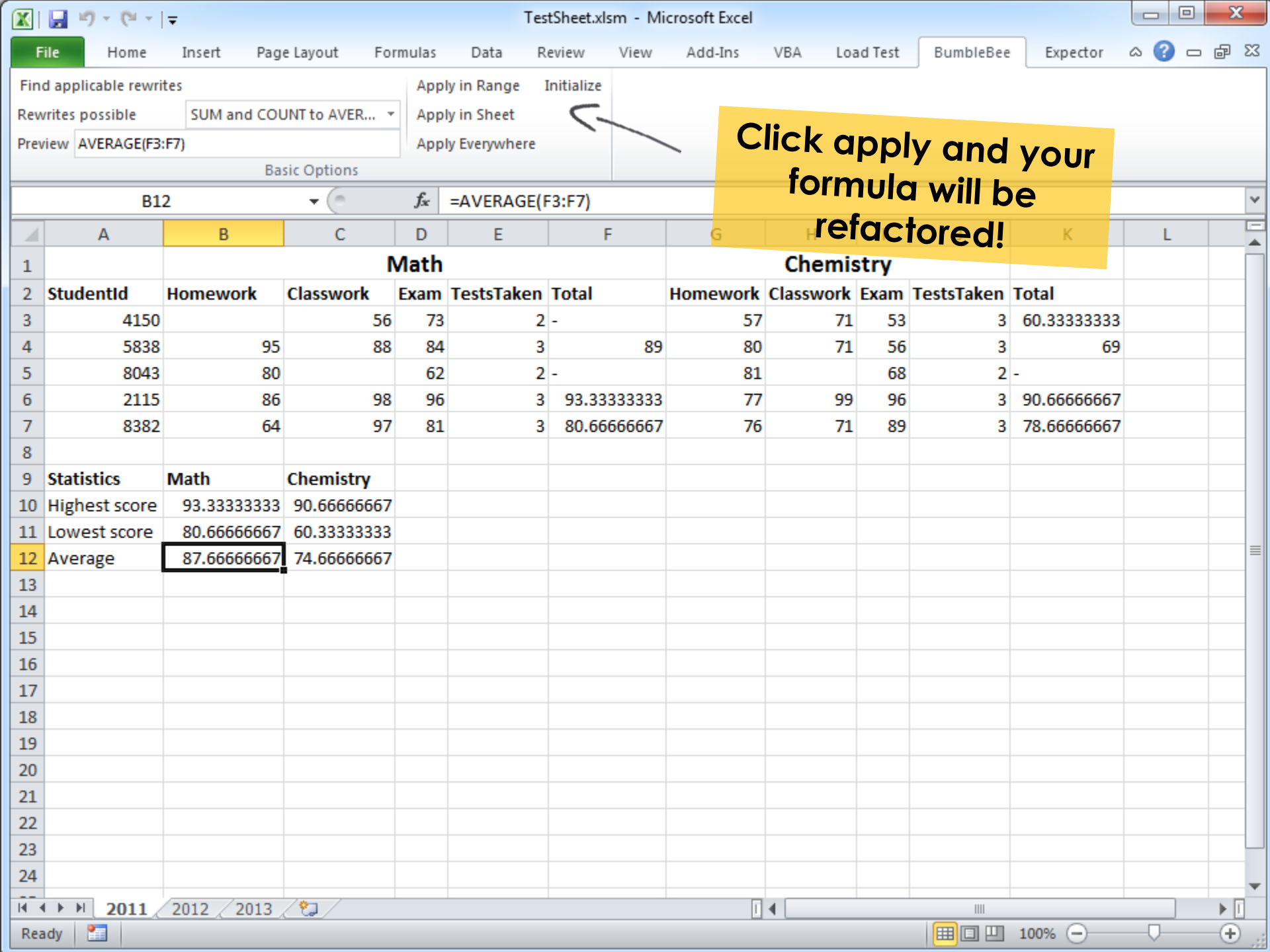
Find applicable rewrites
Rewrites possible
SUM and COUNT to AVER...
Preview
AVERAGE(F3:F7)
Basic Options
Apply in Range
Initialize
Apply in Sheet
Apply Everywhere
And shows you how the new formula will look like
B12
=SUM(F3:F7)/COUNT(F3:F7)
Math
Chemistry
StudentId
Homework
Classwork
Exam
TestsTaken
Total
4150 56 73 2 - 57 71 53 3 60.33333333
5838 95 88 84 3 89 80 71 56 3 69
8043 80 62 2 - 81 68 2 -
2115 86 98 96 3 93.33333333 77 99 96 3 90.66666667
8382 64 97 81 3 80.66666667 76 71 89 3 78.66666667
Statistics
Math
Chemistry
Highest score 93.33333333 90.66666667
Lowest score 80.66666667 60.33333333
Average 87.66666667 74.66666667
2011
2012
2013
Ready
100%



	A	B	C	D	E	F	G	H	I	J	K	L
1		Math					Chemistry					
2	StudentId	Homework	Classwork	Exam	TestsTaken	Total	Homework	Classwork	Exam	TestsTaken	Total	
3	4150		56	73	2	-	57	71	53	3	60.33333333	
4	5838	95	88	84	3	89	80	71	56	3	69	
5	8043	80		62	2	-	81		68	2	-	
6	2115	86	98	96	3	93.33333333	77	99	96	3	90.66666667	
7	8382	64	97	81	3	80.66666667	76	71	89	3	78.66666667	
8												
9	Statistics	Math	Chemistry									
10	Highest score	93.33333333	90.66666667									
11	Lowest score	80.66666667	60.33333333									
12	Average	87.66666667	74.66666667									
13												
14												
15												
16												
17												
18												
19												
20												
21												
22												
23												
24												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Find applicable rewrites
Rewrites possible
SUM and COUNT to AVER...
Preview
AVERAGE(F3:F7)
Basic Options
Apply in Range
Apply in Sheet
Apply Everywhere
Initialize
Click apply and your formula will be refactored!
B12
=AVERAGE(F3:F7)
Math
Chemistry
StudentId
Homework
Classwork
Exam
TestsTaken
Total
4150 56 73 2 - 57 71 53 3 60.33333333
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Highest score 93.33333333 90.66666667
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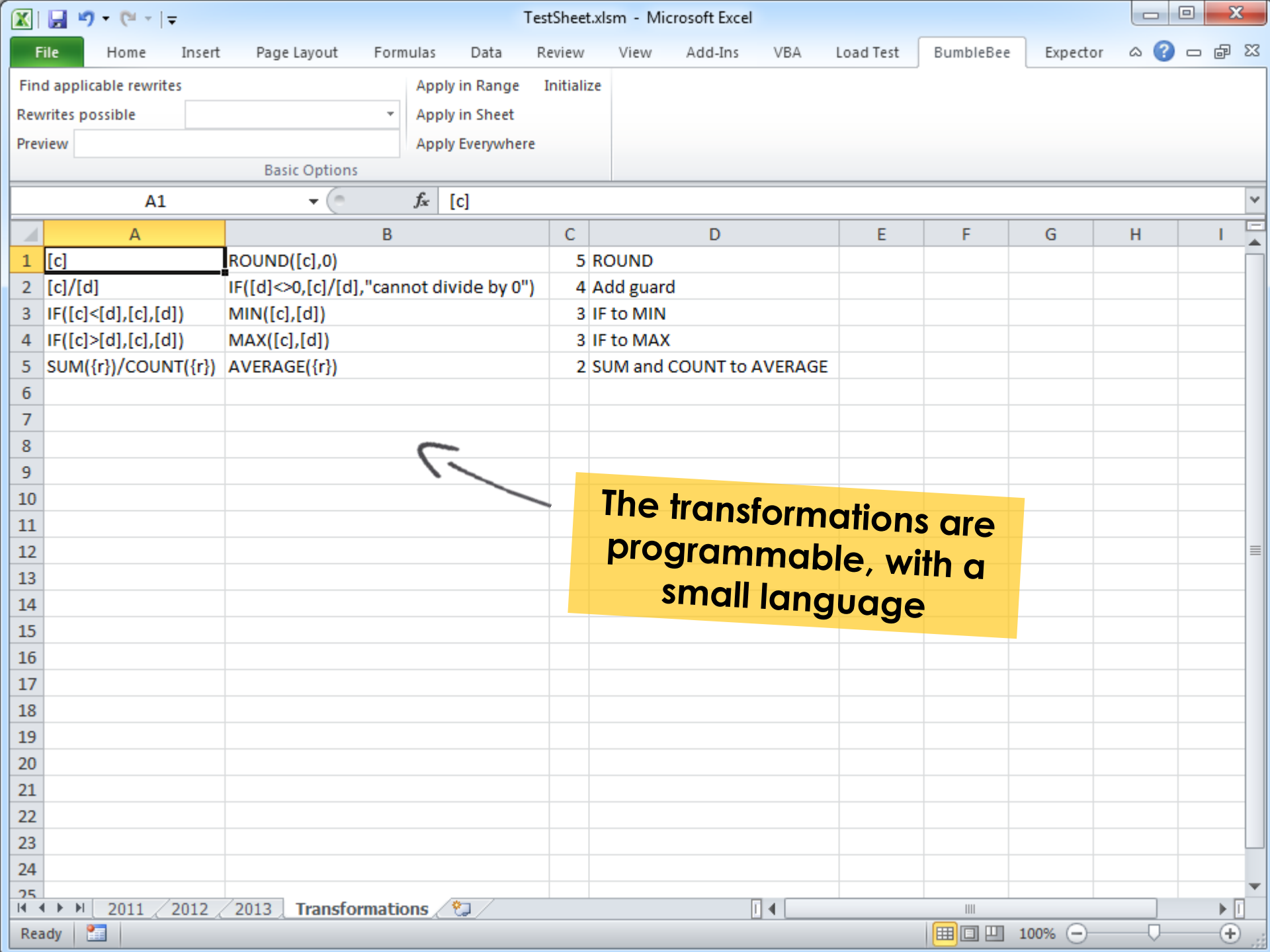
Average 87.66666667 74.66666667
2011
2012
2013
Ready
100%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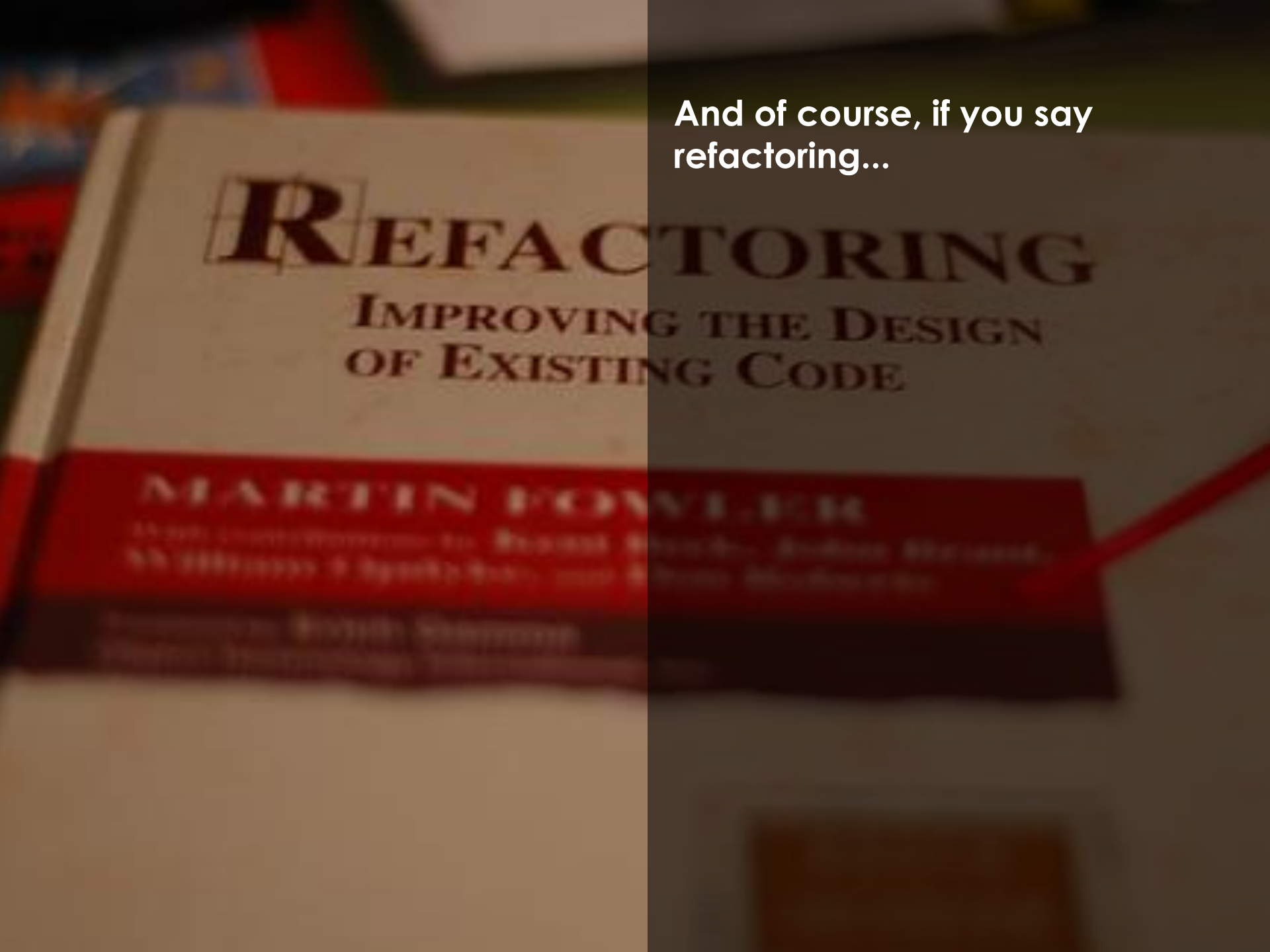
Apply in Sheet
Apply Everywhere
A1
[c]
ROUND([c],0) 5 ROUND
[c]/[d] IF([d]<>0,[c]/[d],"cannot divide by 0") 4 Add guard
IF([c]<[d],[c],[d]) MIN([c],[d]) 3 IF to MIN
IF([c]>[d],[c],[d]) MAX([c],[d]) 3 IF to MAX
SUM({r})/COUNT({r}) AVERAGE({r}) 2 SUM and COUNT to AVERAGE
The transformations are programmable, with a small language
2011
2012
2013
Transformations
Ready
100%



And of course, if you say refactoring...

And of course, if you say refactoring, you say testing!

When users modify their spreadsheet, theywant to be sure the fuinctionality of their spreadsheets remains the same.

But how to get end-users to test?

This is already hard for professional developers!

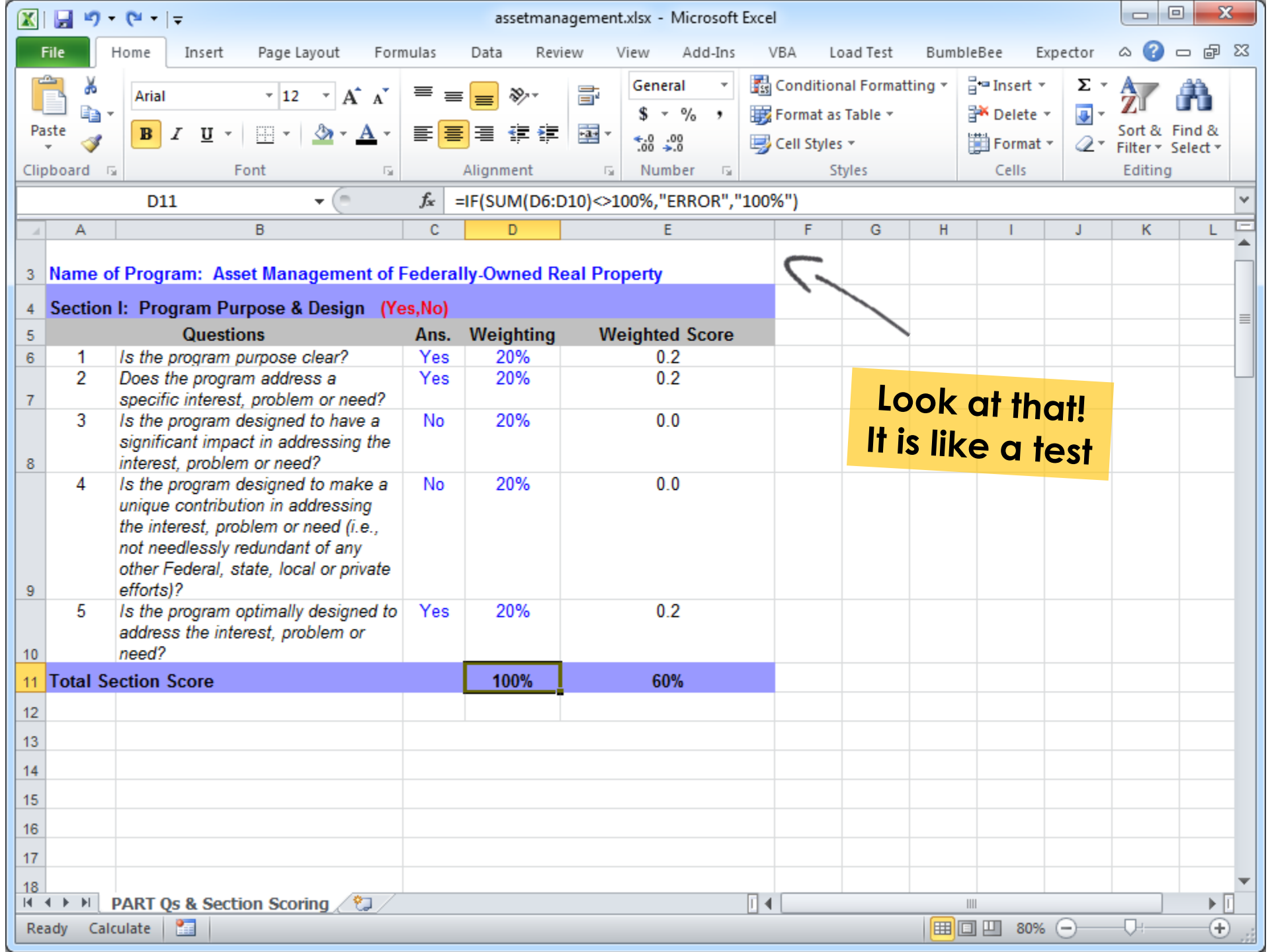
And of course, if you say refactoring, you say testing!

When users modify their spreadsheet, theywant to be sure the fuinctionality of their spreadsheets remains the same.

But how to get end-users to test?

This is already hard for professional developers!

But spreadsheet users are already good testers!


assetmanagement.xlsx - Microsoft Excel
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BumbleBee
Expector
Paste
Clipboard
Arial
12
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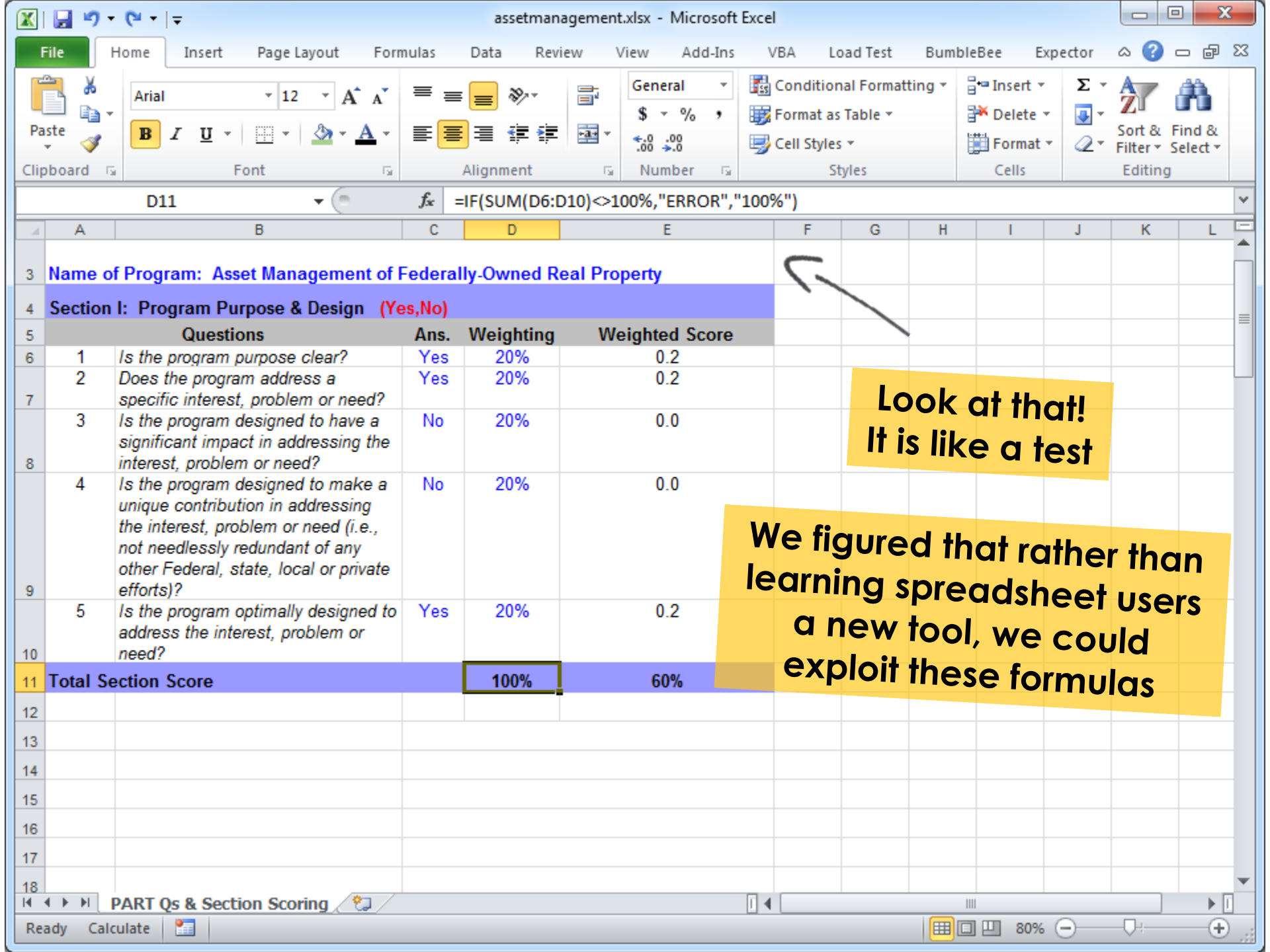
Alignment
General
Number
Conditional Formatting
Format as Table
Cell Styles
Styles
Insert
Delete
Format
Cells
Sort & Filter
Find & Select
Editing
D11
=IF(SUM(D6:D10)<>100%,"ERROR","100%")
Name of Program: Asset Management of Federally-Owned Real Property
Section I: Program Purpose & Design (Yes,No)
Questions
Ans.
Weighting
Weighted Score
1 Is the program purpose clear? Yes 20% 0.2
2 Does the program address a specific interest, problem or need? Yes 20% 0.2
3 Is the program designed to have a significant impact in addressing the interest, problem or need? No 20% 0.0
4 Is the program designed to make a unique contribution in addressing the interest, problem or need (i.e., not needlessly redundant of any other Federal, state, local or private efforts)? No 20% 0.0
5 Is the program optimally designed to address the interest, problem or need? Yes 20% 0.2
Total Section Score 100% 60%
Look at that!
It is like a test
PART Qs & Section Scoring
Ready
Calculate
80%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5 Is the program optimally designed to address the interest, problem or need? Yes 20% 0.2
Total Section Score 100% 60%
Look at that!
It is like a test
We figured that rather than learning spreadsheet users a new tool, we could exploit these formulas
PART Qs & Section Scoring
Ready
Calculate
80%

assetmanagement.xlsx - Microsoft Excel

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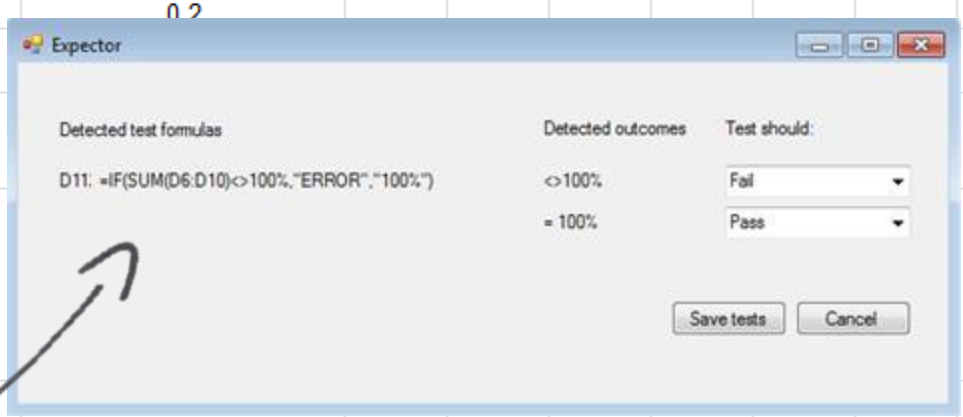
Find Tests
Mark Tests
Mark Covered Formulas
Mark Non-Covered Formulas

D11 =IF(SUM(D6:D10)<>100%,"ERROR","100%")

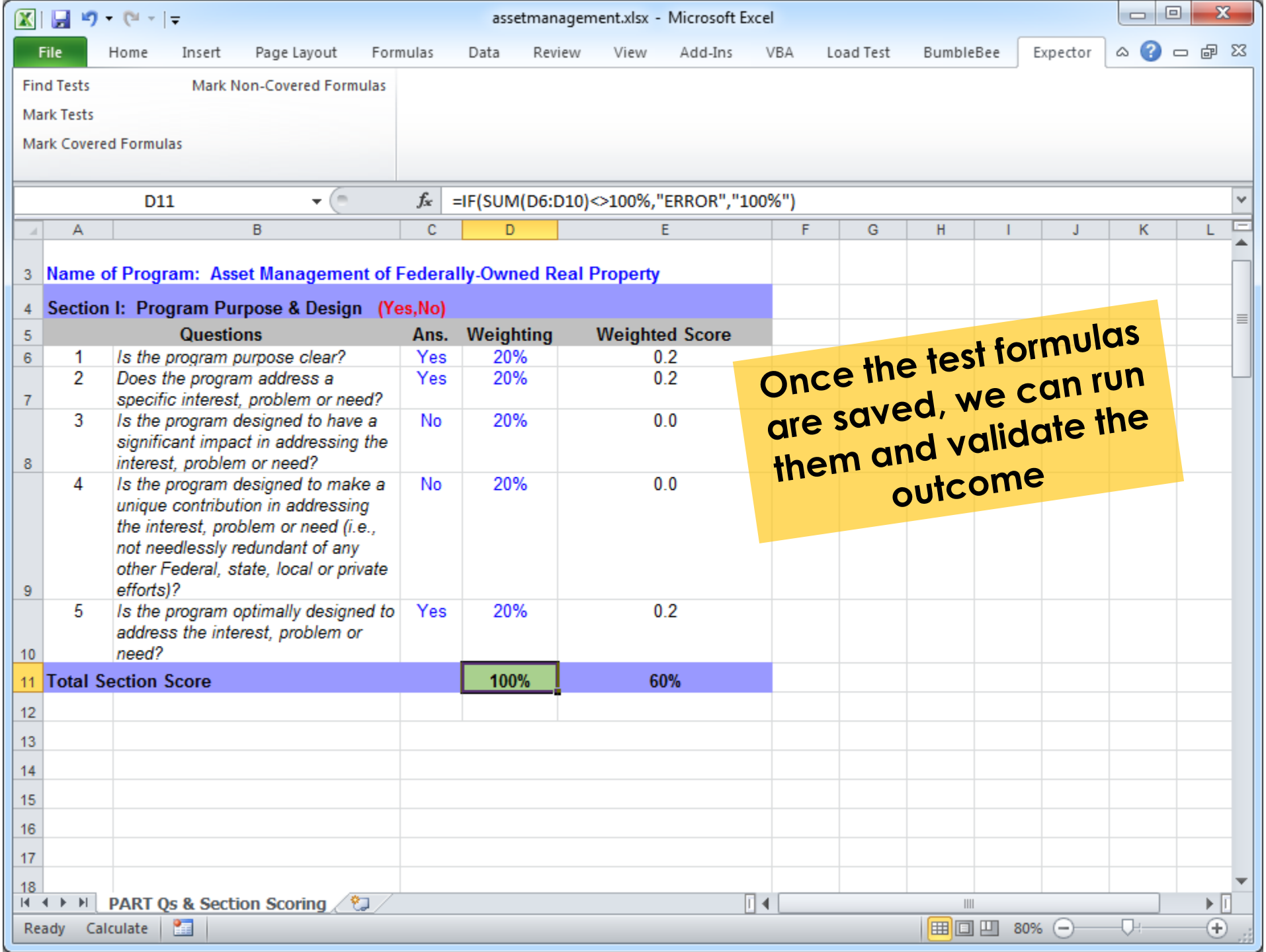
	A	B	C	D	E
3	Name of Program: Asset Management of Federally-Owned Real Property				
4	Section I: Program Purpose & Design (Yes,No)				
5		Questions	Ans.	Weighting	Weighted Score
6	1	*Is the program purpose clear?*	Yes	20%	0.2
7	2	*Does the program address a specific interest, problem or need?*	Yes	20%	
8	3	*Is the program designed to have a significant impact in addressing the interest, problem or need?*	No	20%	
9	4	*Is the program designed to make a unique contribution in addressing the interest, problem or need (i.e., not needlessly redundant of any other Federal, state, local or private efforts)?*	No	20%	
10	5	*Is the program optimally designed to address the interest, problem or need?*	Yes	20%	
11	Total Section Score			100%	60%



So we built Expector: a tool that can detect these test formulas and save them in a 'test suite'

PART Qs & Section Scoring

Ready Calculate 80%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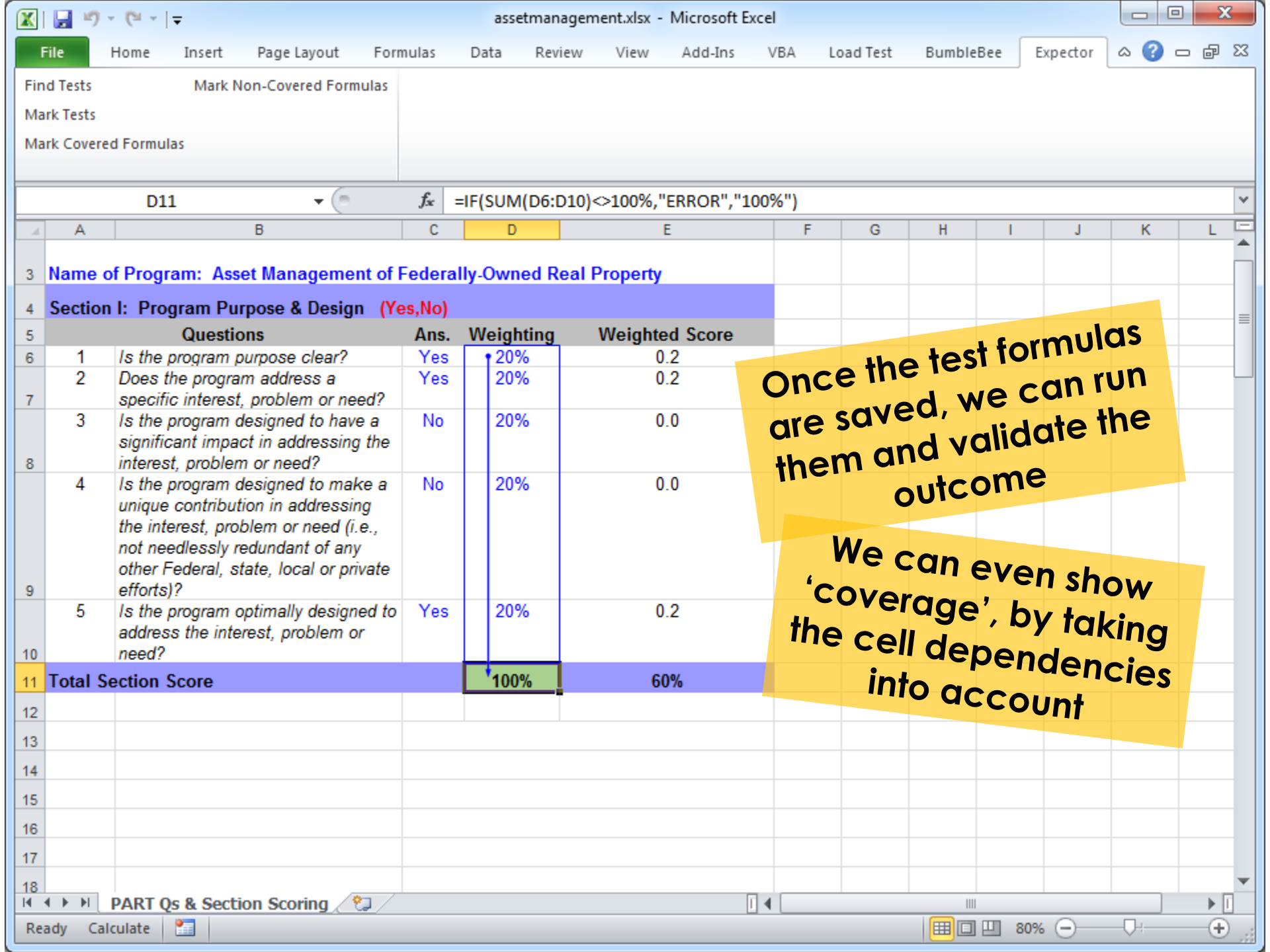
5 Is the program optimally designed to address the interest, problem or need? Yes 20% 0.2
Total Section Score 100% 60%
Once the test formulas are saved, we can run them and validate the outcome
PART Qs & Section Scoring
Ready
Calculate
80%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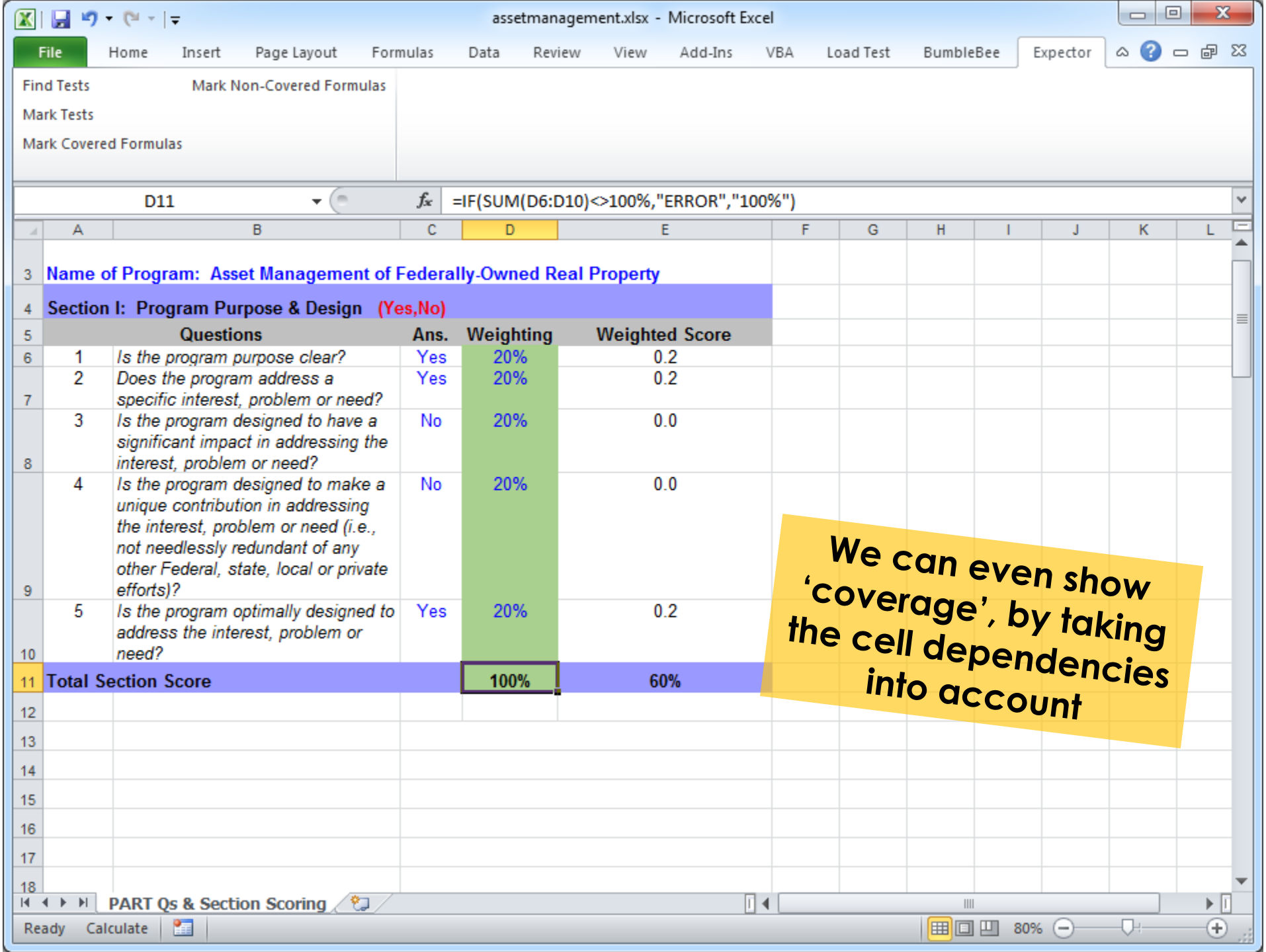
Total Section Score 100% 60%
Once the test formulas are saved, we can run them and validate the outcome
We can even show 'coverage', by taking the cell dependencies into account
PART Qs & Section Scoring
Ready
Calculate
80%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We can even show 'coverage', by taking the cell dependencies into account
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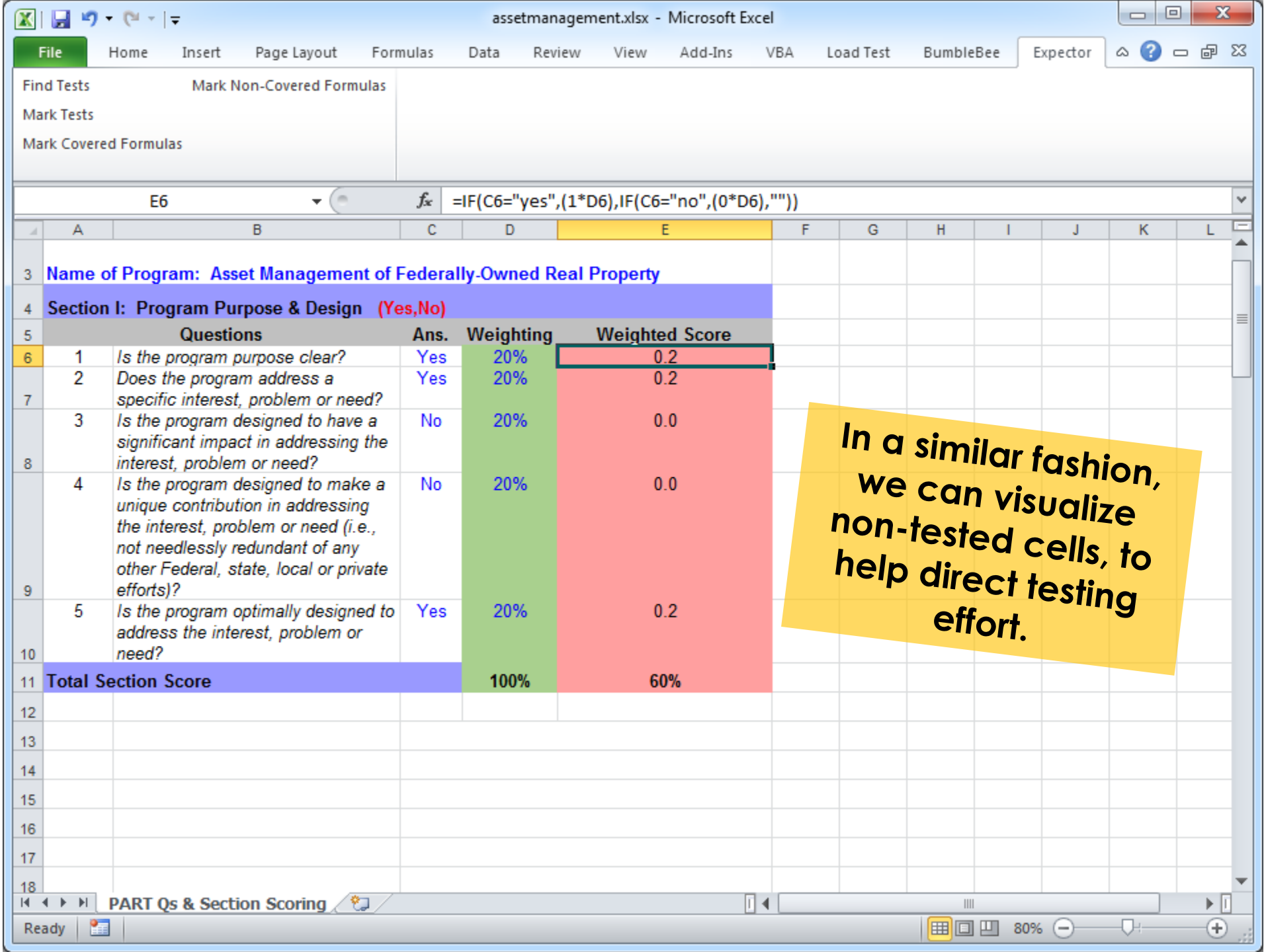
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E6
=IF(C6="yes",(1*D6),IF(C6="no",(0*D6),""))
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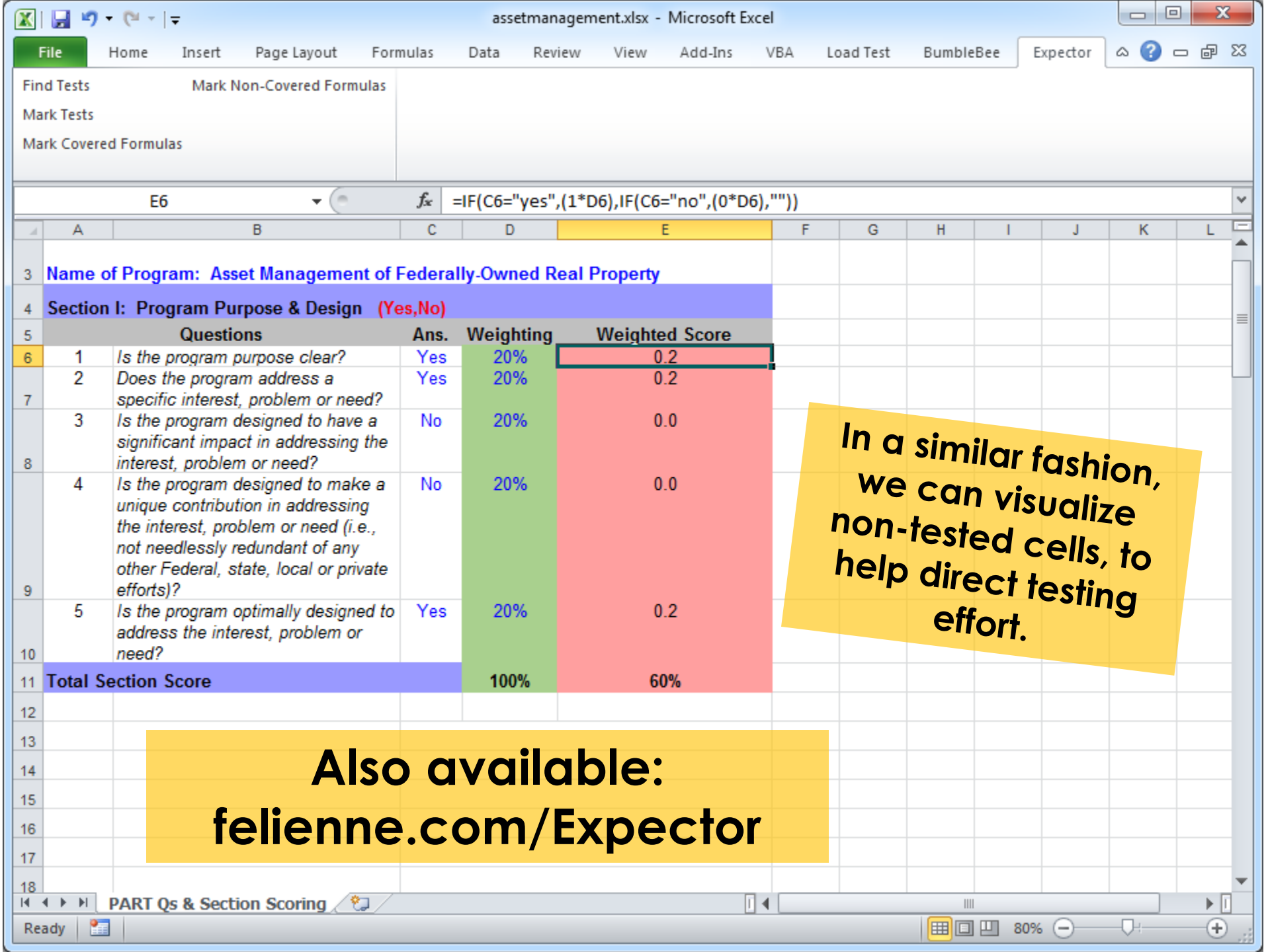
5 Is the program optimally designed to address the interest, problem or need? Yes 20% 0.2
Total Section Score 100% 60%
In a similar fashion, we can visualize non-tested cells, to help direct testing effort.
PART Qs & Section Scoring
Ready
80%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Total Section Score 100% 60%
In a similar fashion, we can visualize non-tested cells, to help direct testing effort.
Also available: felienne.com/Expector
PART Qs & Section Scoring
Ready
80%

That's all folks! Thanks for watching my talk on SlideShare!

Don't forget that:

Spreadsheets are code

More info?

- www.felienne.com
- www.spreadsheetlab.org

Want to connect?

- @felienne
- mail@felienne.com