

**CSCI 1377**

# **Tools for Thought**


# **Programming I: Spreadsheets**

“VisiCalc represented a new idea of a way to use a computer and a new way of thinking about the world. Where conventional programming was thought of as a sequence of steps, this new thing was no longer sequential in effect: When you made a change in one place, all other things changed instantly and automatically.

— Ted Nelson,  
*Whole Earth Software  
Catalog* (1984)

# Spreadsheets are the foundation of personal computing

“There have been two real explosions that propelled the industry forward. The first one really happened in 1977, and it was the spreadsheet. [...] [VisiCalc] really propelled the Apple II to the success it achieved.” — Steve Jobs



The screenshot shows a red header for 'The Register' with a search icon and a menu icon. Below the header, the word 'SOFTWARE' is displayed in a bold, black font. To the right of 'SOFTWARE' is a red underline with the number '132' and a comment icon. A black box with white text reads 'This article is more than 1 year old'. The main text of the article snippet is: 'The nightmare is real: 'Excel formulas are the world's most widely used programming language,' says Microsoft'.

Poll in 2022: office workers report spending ~1/3 of their workday in Excel

Jobs quote: [https://www.youtube.com/watch?v=IU96Pd\\_npn4](https://www.youtube.com/watch?v=IU96Pd_npn4)

Excel study: <https://www.acuitytraining.co.uk/news-tips/new-excel-facts-statistics/>

# The hallmark of a spreadsheet is its flexibility

↑ [-] [beyphy](#) 48 1 point 3 years ago

Just today I created a spreadsheet to try to calculate how many cups of coffee I'd need to have to break even on a relatively espresso / coffee machine I bought. I factored in including the cost of a latte, roundtrip mileage

↑ [-] [depressedbee](#) 10 7 points 3 years ago

A bread recipe db with ability to modify the baker's %.

↑ [-] [werdunloaded](#) 3 30 points 3 years ago

I catalogued my closet! Type of clothing brand, style, material composition, comfort level, fit level, if it's been tailored or not, wash options, dry options, ironing

report reply

↑ [-] [k75ct](#) 2 points 3 years ago

I downloaded information from Ancestry.com so I can sort by burial town and last name I access the file on my phone and visit grave yards to capture headstone pics of my ar

invitees, counts of who invited

needs for upload), group into

d meals but the websites do that

↑ [-] [rmcdm](#) 1 point 3 years ago

↑ [-] [AureliusNoNotMarcus](#) 7 points 3 years ago

I use it to track grades and see how much I can afford to slack off and still earn a good grade

I have a macro that changes the color of each cell from learning more VBA to see how much of each colour is left, to

# Ore Signatures

## Average Frontier Deposit

Ore Signature		Effect(s)			Orbit			Blue Loot	\$4,200,000						
Qty	Sleeper	Class	Scram	Web	Neut	RRep	Sig	Speed	Distance	Velocity	DPS	Alpha	EHP	ISK/EHP	\$149
<b>Defenders</b>															
3	Emergent Patroller	F					35	1,750	8,000	250	16	115	3,000	Ore Value	\$1,658,250,000
1	Awakened Patroller	C													
		<b>Units</b>													
<b>Ore</b>															
	Arkonor	30,000	48												
	Bistot	40,000	64												
	Crokite														
	Dark Ochre														
	Gneiss	450,000	2,2												
	Hedbergite														
	Hemorphite														
	Jaspert														
	Kernite	300,000	36												
	Mercoxite														
	Omber	300,000	18												
	Plagioclase														
	Pyroxeres	700,000	21												
	Scordite														
	Spodumain														
	Veldspar														

# 'EVE Online's spreadsheets in space now integrate seamlessly with Microsoft Excel

It's the first (and maybe last) native Excel add-in for a video game.

**Will Shanklin**

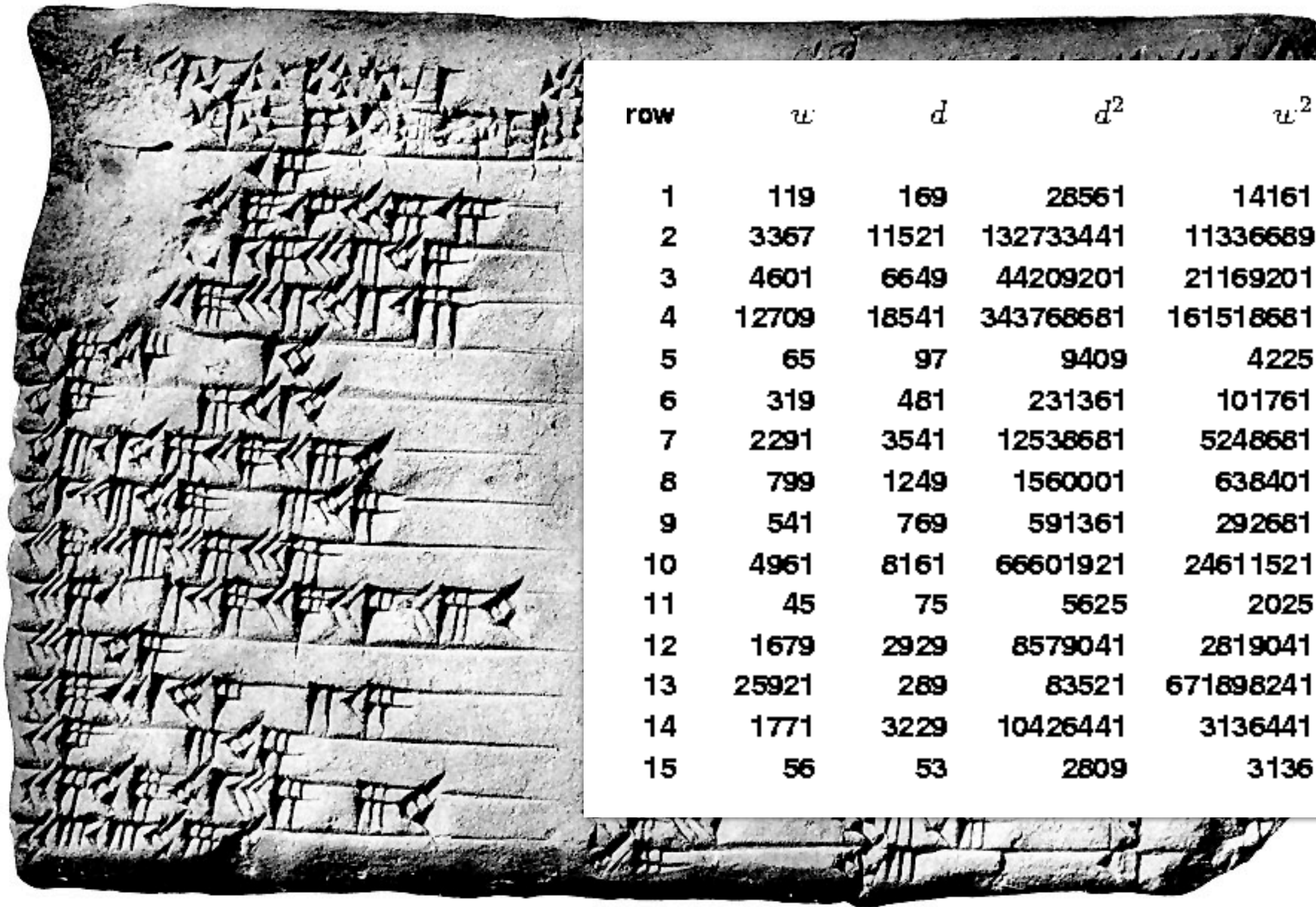
Contributing Reporter



Add Engadget on Google



# Plimpton 322 is an ancient spreadsheet



row	$w$	$d$	$d^2$	$w^2$	$L = d^2 - w^2$	$\ell = \lfloor \sqrt{L} \rfloor$	$\ell^2$
1	119	169	28561	14161	14400	120	14400
2	3367	11521	132733441	11336689	121396752	11018	[121396324]
3	4601	6649	44209201	21169201	23040000	4800	23040000
4	12709	18541	343768681	161518681	182250000	13500	182250000
5	65	97	9409	4225	5184	72	5184
6	319	481	231361	101761	129600	360	129600
7	2291	3541	12538681	5248681	7290000	2700	7290000
8	799	1249	1560001	638401	921600	960	921600
9	541	769	591361	292681	298680	546	[298116]
10	4961	8161	66601921	24611521	41990400	6480	41990400
11	45	75	5625	2025	3600	60	3600
12	1679	2929	8579041	2819041	5760000	2400	5760000
13	25921	289	83521	671898241	-671814720	[-]	[-]
14	1771	3229	10426441	3136441	7290000	2700	7290000
15	56	53	2809	3136	-327	[-]	[-]

# Paper ledgers were known as “spread sheets”

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Courtier J. de la Halle

M<sup>rs</sup> Camille Vassogne  
cave à Beauvegard

Mise en gare de : ...  
Mise au canal de : ...

Camionneur J. Jolly

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Conditions du Marché		Acomptes	Retiraisons					Payements		Destination des Vins retirés				
Date	Quantité		Date	Quantité	Prix	Montants	Date	Montant	Expédié à	Quantité	Prix	Montants		
12 Oct. 1920														
<p>Report</p> <p>500 de ...</p> <p>... ..</p> <p>... ..</p> <p>... ..</p>														
<p>Courtier J. de la Halle</p> <p>M<sup>rs</sup> Paul Gachon Cave à Gallargues</p> <p>Mise en gare de : ... Mise au canal de : ...</p> <p>Camionneur J. Jolly</p>														
12 Oct. 1920														
<p>Report</p> <p>500 de ...</p> <p>... ..</p> <p>... ..</p> <p>... ..</p>														
<p>Courtier J. de la Halle</p> <p>M<sup>rs</sup> Paul Moynier Cave à Candillargues</p> <p>Mise en gare de : ... Mise au canal de : ...</p> <p>Camionneur J. Jolly</p>														
12 Oct. 1920														
<p>Report</p> <p>500 de ...</p> <p>... ..</p> <p>... ..</p> <p>... ..</p>														
<p>Total à reporter</p>														

# VisiCalc (1979) took the industry by storm

C11 (L) TOTAL 251

A	B	C	D
ITEM	NO.	UNIT	COST
---	---	---	---
MUCK RAKE	4	12.95	51.80
FOUNTON	1	1248.00	1248.00
EYEFINK TONER	25	49.95	1248.75
EYEFINK SNUFF	2	9.95	19.90
			-----
		SUBTOTAL	13155.50
		9.75% TAX	1282.66
			-----
		<b>TOTAL</b>	<b>14438.16</b>

D6  $\text{fx} = \text{SUM}(D2:D4)$

	A	B	C	D
1	Item	Unit Price	Quantity	Total Price
2	Bacon	\$11	2	\$24
3	Eggs	\$8	4	\$35
4	Cheese	\$5	10	\$54
5				
6	Sales tax		Subtotal	\$112
7	0.08			

Example of Cash Budget  
ABC Corporation - For the Quarter Ended September 30, 1960

<u>Raw Data:</u>	<u>May</u>	<u>June</u>	<u>July</u>	<u>August</u>	<u>September</u>	<u>Total for Quarter</u>
Sales (credit)	\$45,000	\$42,500	\$40,000	\$65,000	\$70,000	\$175,000
Purchases (on account)	27,000	27,000	24,000	27,000	30,000	81,000
<u>Receipts:</u>						
Collections (previous month's sales, i.e., assumed 30-day collection period)			\$ 42,500	\$ 40,000	\$ 65,000	\$147,500
Proceeds from sale of common stock			-	-	5,000	5,000
Proceeds from additional long-term debt issued			-	-	10,000	10,000
Total receipts			<u>\$ 42,500</u>	<u>\$ 40,000</u>	<u>\$ 80,000</u>	<u>\$162,500</u>
<u>Disbursements:</u>						
Payment for purchases (staggered by 1-1/3 months, i.e., payments made after 40 days)			\$ 27,000*	\$ 25,000	\$ 26,000	\$ 78,000
Outlays for labor (as per monthly operating plan)			10,500	11,500	12,500	34,500
Overhead (cash outlays per month)			10,000	10,500	11,000	31,500
Selling expense (outlays per sales department budget)			5,000	5,000	6,000	16,000
General & administrative expense (outlays as per administrative budget)			5,000	5,000	5,000	15,000
Interest payments (due in September)			-	-	500	500
Payments for purchase of machinery (scheduled for August)			-	3,500	-	3,500
Dividends paid (scheduled for September)			-	-	2,000	2,000
Total disbursements			<u>\$ 57,500</u>	<u>\$ 60,500</u>	<u>\$ 63,000</u>	<u>\$181,000</u>
Net receipts (disbursements)			<u>\$(15,000)</u>	<u>\$(20,500)</u>	<u>\$ 17,000</u>	<u>\$(18,500)</u>
Cumulative net effect on cash			<u>(15,000)</u>	<u>(35,500)</u>	<u>(18,500)</u>	<u>(18,500)</u>

[youtu.be/YDvbDiJZpy0](https://youtu.be/YDvbDiJZpy0)

# Spreadsheets show data and hide the code

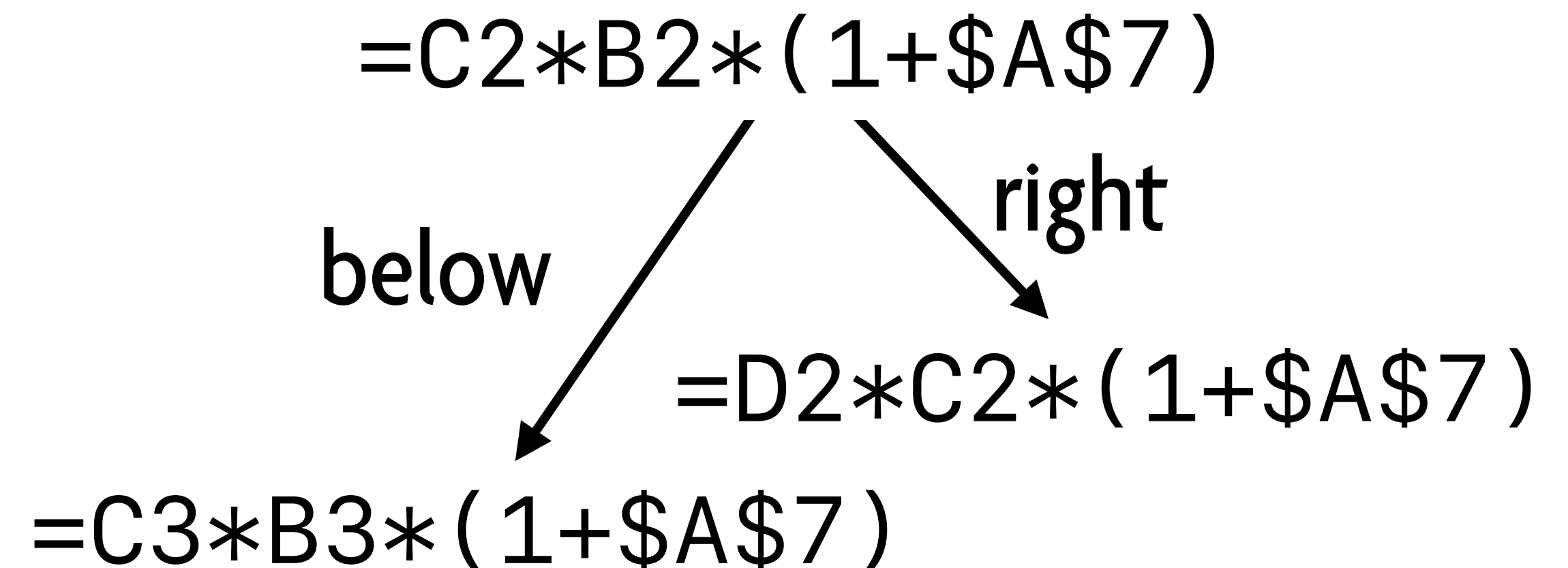
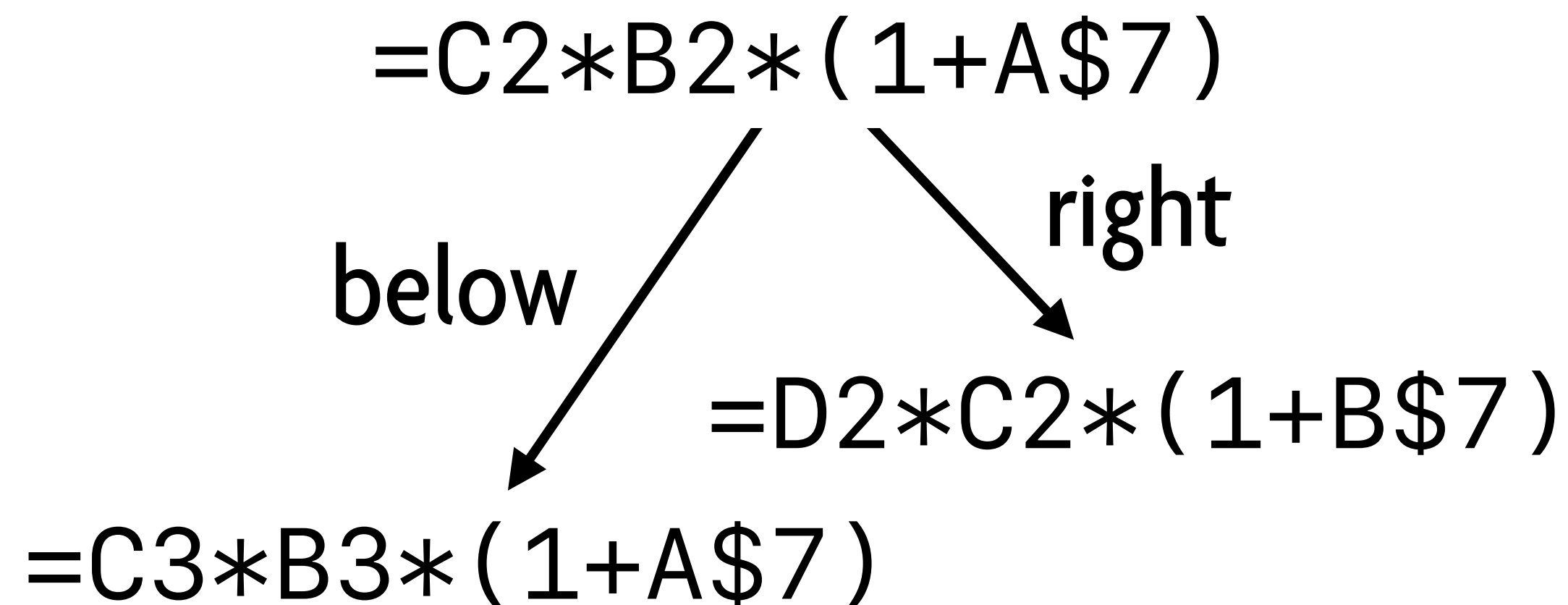
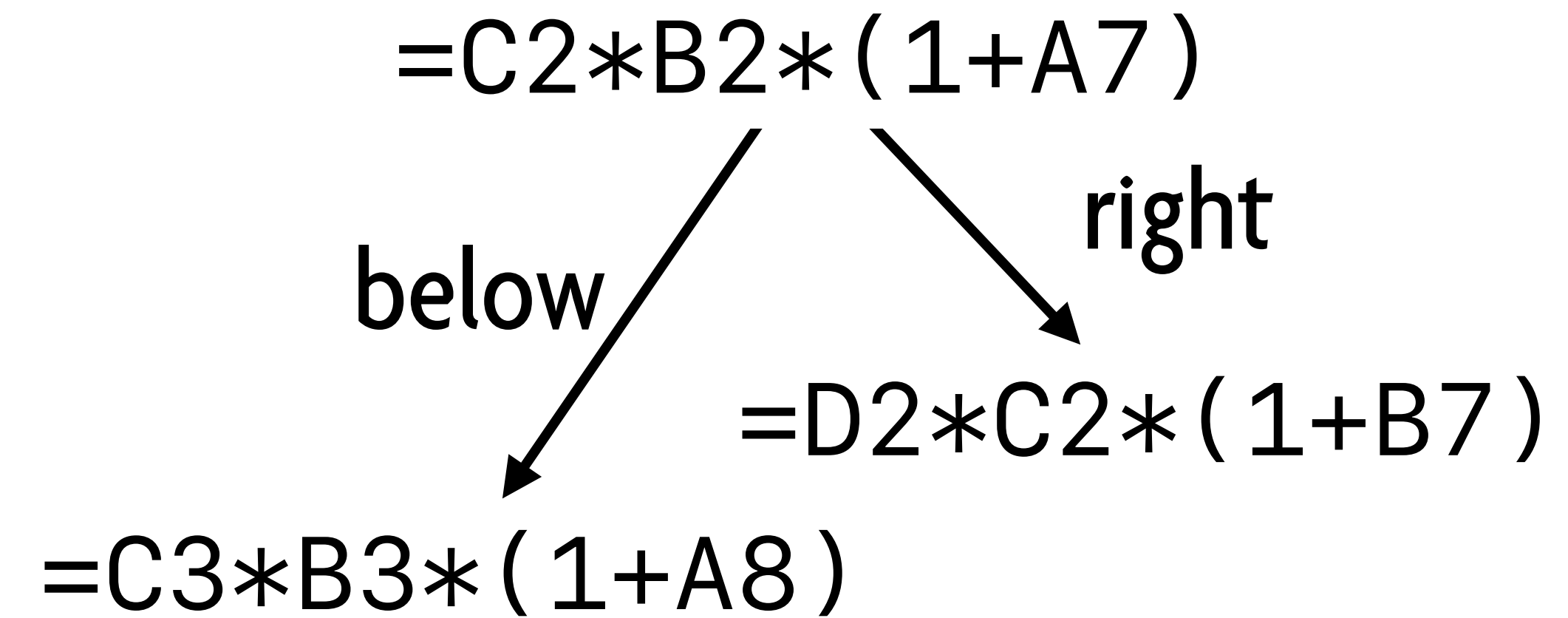
	A	B	C	D
1	<b>Item</b>	<b>Unit Price</b>	<b>Quantity</b>	<b>Total Price</b>
2	Bacon	\$11	2	\$24
3	Eggs	\$8	4	\$35
4	Cheese	\$5	10	\$54
5				
6	<b>Sales tax</b>		<i>Subtotal</i>	\$112
7	0.08			

```
items = ["Bacon", "Eggs", "Cheese"]
prices = [11, 8, 5]
quantities = [2, 4, 10]
sales_tax = 0.08
total_prices = []
subtotal = 0
```

```
for (price, qty) in zip(prices, quantities):
    total_price = price * qty * (1 + sales_tax)
    total_prices.append(total_price)
    subtotal += total_price
```

# Spreadsheets use templates over abstraction

D6    fx =SUM(D2:D4)				
	A	B	C	D
1	<b>Item</b>	<b>Unit Price</b>	<b>Quantity</b>	<b>Total Price</b>
2	Bacon	\$11	2	\$24
3	Eggs	\$8	4	\$35
4	Cheese	\$5	10	\$54
5				
6	<b>Sales tax</b>		<i>Subtotal</i>	\$112
7	0.08			



# Copy-paste does not always map to task

	A	B	C
<b>Block 1</b>	1	XXX	=AVG(B1..B50)
<b>Block 2</b>	100	...	

```
=Average (Range (MakeRange (
  ColOf ($B$1), RowOf ($B$1) + $H$5 * (Row () - RowOf ($B$1) ),
  ColOf ($B$1), RowOf ($B$1) + $H$5 * (Row () - RowOf ($B$1) + 1) - 1) ) )
```

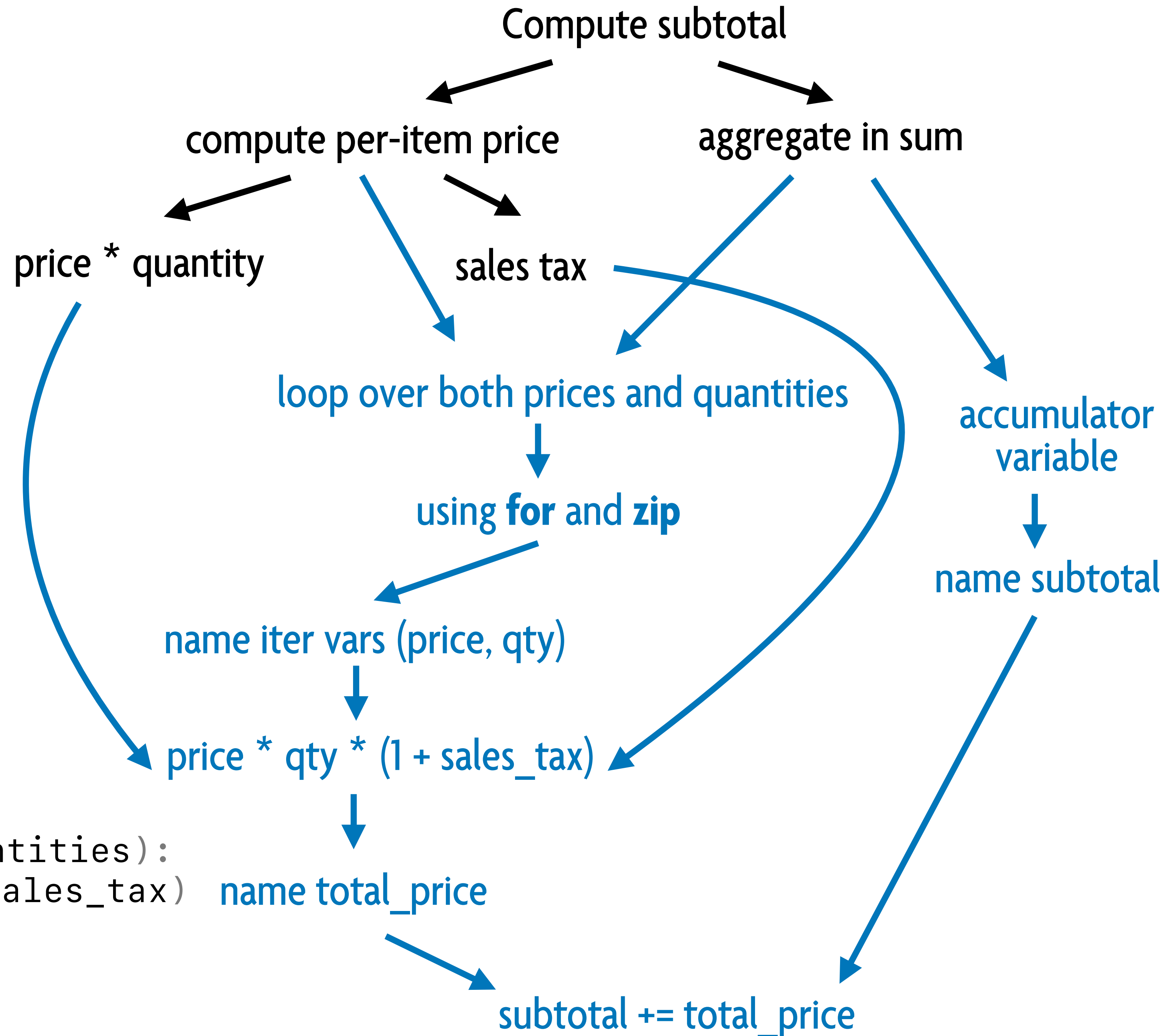
C = B.chunks(50).map(avg)

“I ought to be able to copy that formula, but of course if you do that, you wouldn’t get what you wanted because [you would get the average of rows 1-50 in C1, 2-51 in C2, and so on]”

# A plan composition analysis of the Python program

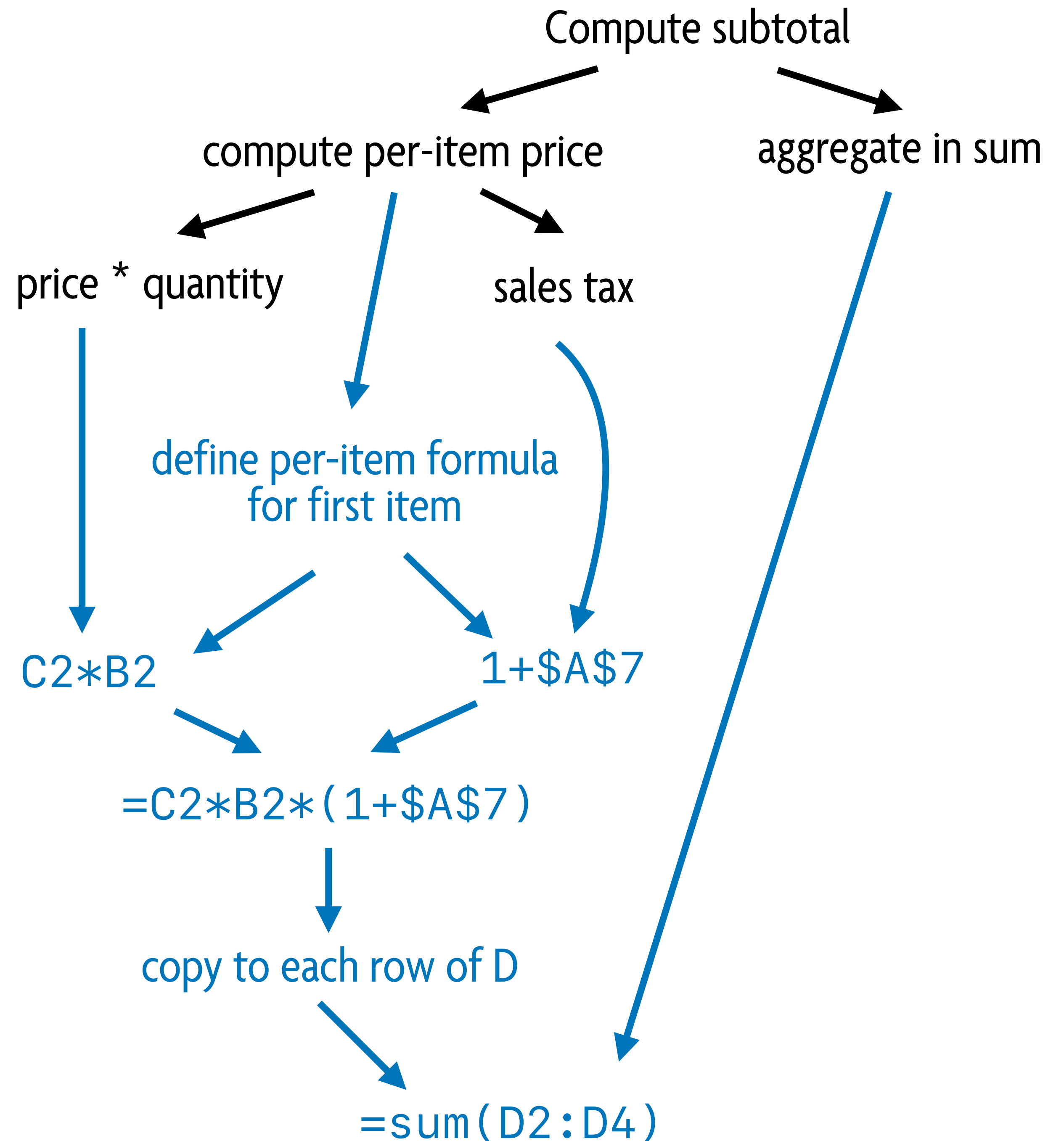
```
items = ["Bacon", "Eggs", "Cheese"]
prices = [11, 8, 5]
quantities = [2, 4, 10]
sales_tax = 0.08
total_prices = []
subtotal = 0
```

```
for (price, qty) in zip(prices, quantities):
    total_price = price * qty * (1 + sales_tax)
    total_prices.append(total_price)
    subtotal += total_price
```



# A plan composition analysis of the spreadsheet program

	A	B	C	D
1	Item	Unit Price	Quantity	Total Price
2	Bacon	\$11	2	\$24
3	Eggs	\$8	4	\$35
4	Cheese	\$5	10	\$54
5				
6	Sales tax		Subtotal	\$112
7	0.08			



# **Studies on spreadsheet use**

# Model of spreadsheet comprehension

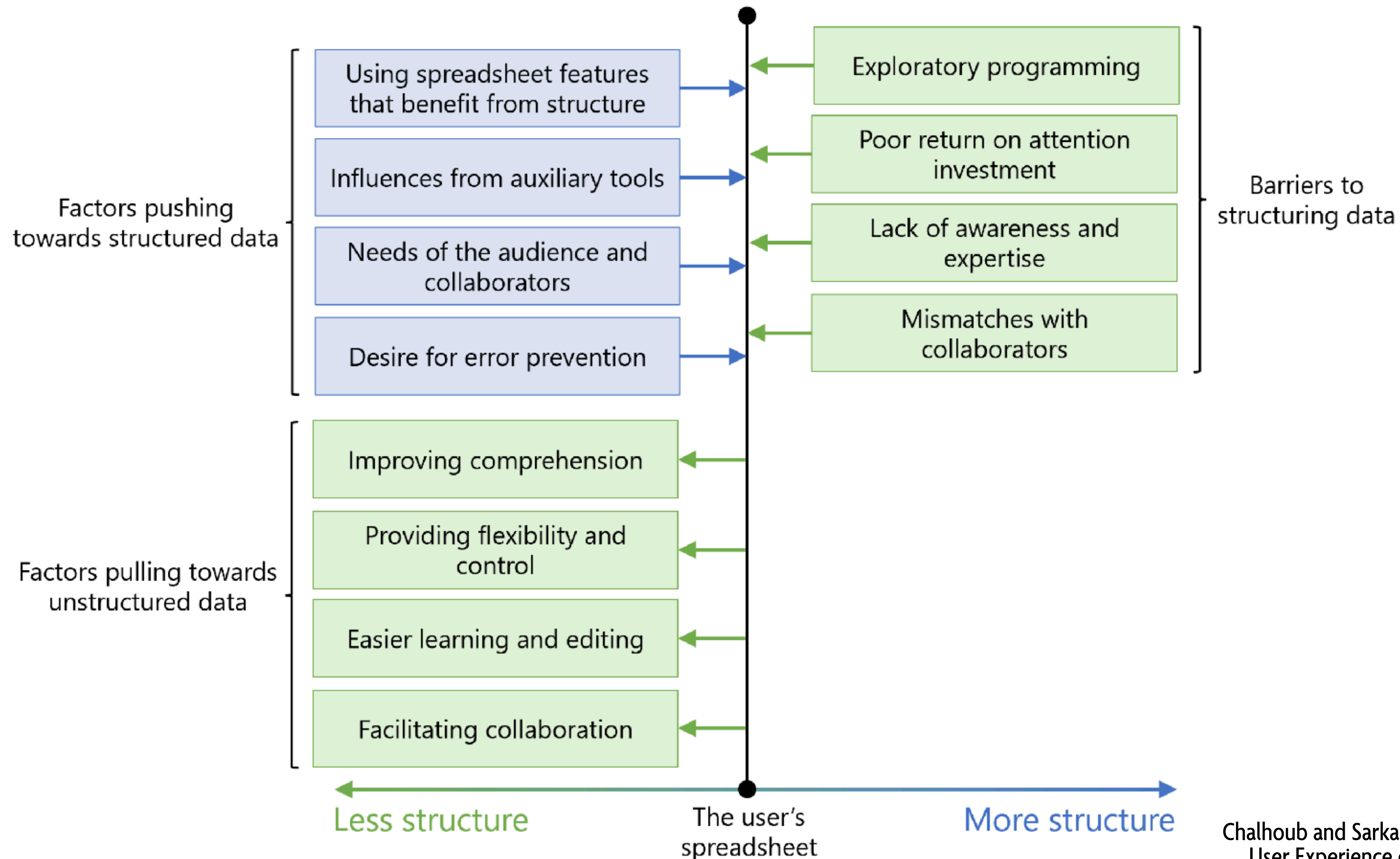
- Choose a cell, usually top-left of a block
- Inspect neighboring cells to see how formula changes
- Study cell formulas, look up unknown cell references
- To look up a cell:
  - Scroll to bring it into view
  - Scan to find its column & row
  - Determine semantics from column & row labels

# Spreadsheets contain info beyond cell values

treated floor area:		4201 m2	630 m2	3571 m2	IHG: 4.1 w/m2											
Time Period	Actual Electrical Energy Use (From BC Hydro)				Suite heating Calculation		Household Electricity	PHPP	estimated distribution							
Start	Finish	days	total (includes parkade)	common (includes parking)	diff from av	Heating	Electricity	Final Energy	total	house (est)	Suites modeled					
			kWhr	kWhr/m2	kWhr	kWhr/m2	kWhr	kWhr/m2	kWhr/yr/m2	kWhr/yr/m2						
1-Mar	31-Mar	31	38,229	107.1	-	0.0	38,229	107.1	heating	7.4	11%	1.11	6.29			
1-Apr	30-Apr	30	34,319	99.4	-	0.0	34,319	99.4	aux heating	2.2	3%	2.20	-			
1-May	31-May	31	32,148	90.1	-	0.0	32,148	90.1	cooling	-	0%	-	-			
1-Jun	30-Jun	30	31,955	92.5	-	0.0	31,955	92.5	aux cooling	1.2	2%	1.20	-			
1-Jul	31-Jul	31	33,737	94.6	-	0.0	33,737	94.6	DHW	32.8	51%	-	-			
1-Aug	31-Aug	31	33,573	94.1	-	0.0	33,573	94.1	aux DHW	0.4	1%	0.4	-			
1-Sep	30-Sep	30	30,334	87.9	-	0.0	30,334	87.9	household electricity	20.4	32%	3.06	17.3			
1-Oct	31-Oct	31	34,054	95.4	-	0.0	34,054	95.4								
1-Nov	30-Nov	30	36,060	104.4	-	0.0	36,060	104.4								
1-Dec	31-Dec	31	39,787	111.5	-	0.0	39,787	111.5								
1-Jan	31-Jan	31	39,098	109.6	-	0.0	39,098	109.6								
1-Feb	28-Feb	28	38,041	118.0	-	0.0	38,041	118.0								
1-Mar	31-Mar	31	34,670	97.2	-	0.0	34,670	97.2								
<b>Annual Electrical Ener</b>	365		417,777	99.4	-	-	417,777	99.4	27,422	6.5	92.9	64.4	100%	8.0	23.6	0.15
PHPP				31.6		8.0		23.6		6.3	17.3					
		<b>monthly average</b>			<b>monthly average</b>		<b>monthly average</b>				<b>monthly average</b>					
		34,806		-		34,806	99.6	2,285	6.56	93.0						
	Per Suite@ 85 suites			-		409		27								

In newer condo buildings, about 50 per cent of the overall electricity use is covered by a common-use account that is funded by strata fees. If the cost appeared on a resident's hydro bill, it could add up to an additional \$40 each month. The average apartment or condo's bill is now \$43 per month. The average single-family home's hydro bill is \$103 per month.

# Structured vs. unstructured data in spreadsheets



# Concepts for new types of spreadsheets

# Logic spreadsheets compute over constraints

Event Title	Logic Group Meeting
Start Time	
End Time	
Duration	

(1)

Event Title	Logic Group Meeting
Start Time	1:00 pm
End Time	
Duration	

(2)

Event Title	Logic Group Meeting
Start Time	1:00 pm
End Time	3:00 pm
Duration	2 hours

(3a)

Event Title	Logic Group Meeting
Start Time	1:00 pm
End Time	3:00 pm
Duration	2 hours

(3b)

**Figure 1** Creating an event. (1) The user first sets the title for the event. (2) The user then sets the start time for the event to 1:00 pm. (3a) In one scenario, the user then sets the end time for the event to 3:00 pm. The duration is then automatically filled in as 2 hours. (3b) In an alternate scenario, the user instead chooses the duration of the event to be 2 hours. The end time of the event is then automatically filled in as 3:00 pm.

# Hierarchical spreadsheets represent nesting

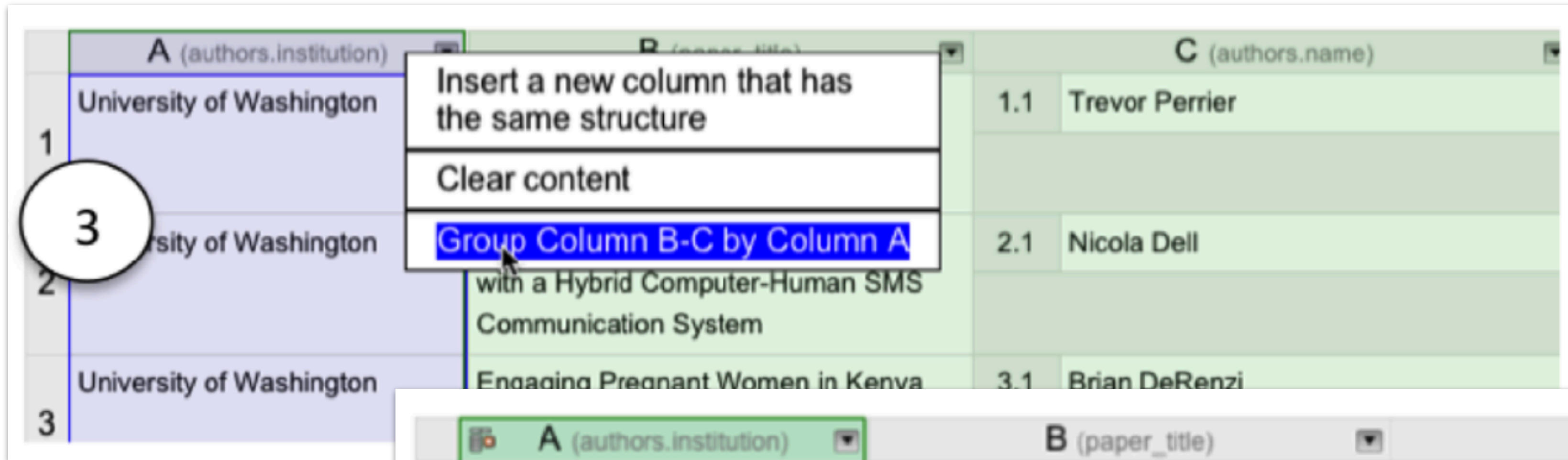
1

A (paper_title)	B (authors.name)	C (authors.institution)
Engaging Pregnant Women in Kenya with a Hybrid Computer-Human SMS Communication System	1.1 Trevor Perrier	1.1 University of Washington
	1.2 Nicola Dell	1.2 University of Washington
	1.3 Brian DeRenzi	1.3 University of Washington
	1.4 Richard Anderson	1.4 University of Washington
	1.5 John Kinuthia	1.5 University of Nairobi
	1.6 Jennifer Unger	1.6 University of Washington
	1.7 Grace John-Stewart	1.7 University of Washington
Long-Term Use of Motion-Based Video Games in Classrooms	2.1 Kathrin M Gerling	2.1 University of Lincoln

2

A (authors.institution)	B (paper_title)	C (authors.name)
University of Washington	Engaging Pregnant Women in Kenya with a Hybrid Computer-Human SMS Communication System	1.1 Trevor Perrier
University of Washington		2.1 Nicola Dell
University of Washington		3.1 Brian DeRenzi
University of Washington		4.1 Richard Anderson

# Hierarchical spreadsheets represent nesting



A screenshot of a spreadsheet with three columns: A (authors.institution), B (paper\_title), and C (authors.name). The data is as follows:

A (authors.institution)	B (paper_title)	C (authors.name)
University of Washington	1.1	Trevor Perrier
University of Washington	2.1	Nicola Dell
University of Washington	3.1	Brian DeRenzi

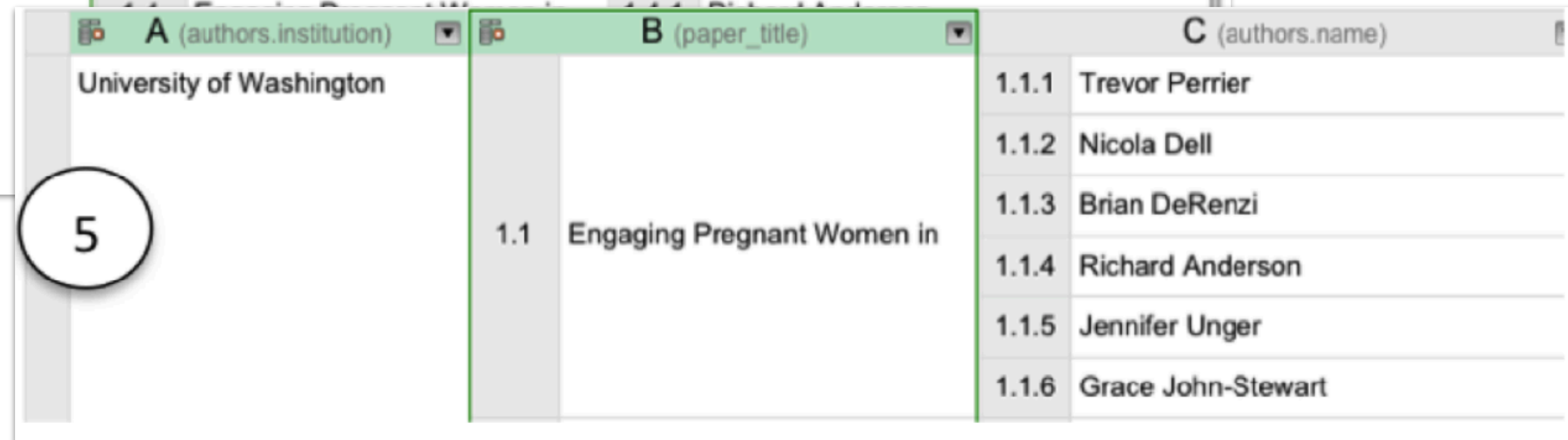
A context menu is open over column B, with the option "Group Column B-C by Column A" highlighted. A circled number "3" is next to the menu.



A screenshot of a spreadsheet showing hierarchical data. Column A is "University of Washington". Column B contains paper titles, and column C contains author names. The data is as follows:

A (authors.institution)	B (paper_title)	C (authors.name)
University of Washington	1.1	Engaging Pregnant Women in
	1.2	Engaging Pregnant Women in
	1.3	Engaging Pregnant Women in

A circled number "4" is next to the spreadsheet.



A screenshot of a spreadsheet showing nested data. Column A is "University of Washington". Column B contains paper titles, and column C contains author names. The data is as follows:

A (authors.institution)	B (paper_title)	C (authors.name)	
University of Washington	1.1 Engaging Pregnant Women in	1.1.1	Trevor Perrier
		1.1.2	Nicola Dell
		1.1.3	Brian DeRenzi
		1.1.4	Richard Anderson
		1.1.5	Jennifer Unger
		1.1.6	Grace John-Stewart

A circled number "5" is next to the spreadsheet.

# Object spreadsheets map OOP to sheets

Room		Occupant			free	
	name	sqFoot		name	role	free
•	text	number	•	text	Role	number
•	Dungeon Five	480	•	Sirius	<u>Grad. student</u>	436
			•	James	<u>Post-doc</u>	
			•	Wormtail	<u>Grad. student</u>	
•	Greenhouse Two	561	•	Bellatrix	<u>Visiting Prof.</u>	476
			•	Lily	<u>Post-doc</u>	
			•	Remus	<u>Post-doc</u>	

Role		
	title	allocSpace
•	text	number
•	Grad. student	12
•	Post-doc	20
•	Visiting Prof.	45

$$\text{Room.free} \hat{=} \text{sqFoot} - \text{sum}[o : \text{Occupant}](o.\text{role.allocSpace})$$

# Ambsheets contain multi-valued cells

	A	B					
1	Budget						
2							
3	Car	$\bar{x} = 850$					
		500	1,200				
4	Apartment	$\bar{x} = 4,000$					
		2,800	3,700	5,500			
5	Netflix	18					
6							
7	TOTAL	$\bar{x} = 4,868$					
		3,318	4,218	6,018	4,018	4,918	6,718
8							
9							

**B7**

`=sum(b3:b5)`

**TABLE**

Aggregate: avg

B3

	500	1,200
2,800	3,318	4,018
3,700	4,218	4,918
5,500	6,018	6,718

**STACKS**

3318 4018 4218 4918 6018 6718

# Spreadsheets in industry

- No real innovation in the interfaces to spreadsheets, afaict
  - Excel has been dominant for almost 40 years now
  - Google Sheets has some adoption among casual users
- Excel has been changing recently w/ PL influence
  - LAMBDA function!
- Spreadsheets as databases, or databases as spreadsheets
  - Airtable, Notion, Coda, ...
  - “Direct manipulation database”