Cost Analysis for Evaluation in Education

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Some Notes Before We Begin

- Acknowledgments: Brooks Bowden, Clive Belfield and Robert Shand
- Objectives:
  - For you
  - For me
- Caution: I talk fast

Today's Workshop

- Some Concepts and Theory:
    - Cost Analysis, Cost-Effectiveness Analysis, and Cost-Benefit Analysis
    - The Ingredients Method
        - Designing a Cost Study
        - Other
        - Additional Resources
        - Case Study (if we have time)
- Lunch + Projects - Cost Analysis

Inform policy not

make policy

Cost Analysis, Cost-Effectiveness Analysis and Benefit-Cost Analysis

Cost Analysis

- Cost Analysis (CA): Description of resources needed to deliver a program
- Research questions:
  - What is the total cost and cost per student of Program X?
  - What portion of the costs are fixed or variable?
  - How does the cost vary by site?
  - What costs were borne by the school?

Cost-Effectiveness Analysis

- Cost-Effectiveness Analysis (CEA): Links program resources to outcomes

- What works at what cost?

- For example:
  - Reducing class size: big effects but high cost
  - New curricula: modest effects but low cost
  - Mentoring: varied effects but varied costs

Cost-Effectiveness Analysis

- Important: CEA is comparative in nature
- Compare policy alternatives based on ratio of their costs to a quantifiable effectiveness measure:

$$\text{CE Ratio} = \$\text{Cost}/\text{Unit of Effectiveness}$$

- Compare policies that target the same unit of effectiveness

Cost-Benefit Analysis

- Cost-Benefit Analysis (CBA): Links costs to economic returns
- CBA evaluated programs as investments
- Report as a social return on investment

Cost-Benefit Analysis

- Economic Benefits:
  - Monetized effectiveness measures
  - Often predicted not measured
  - Distributed across society: positive and negative externalities

- Two key measures of BCA:
  1. BC Ratio: $Benefits/$Cost
  2. Net Benefits=$Benefits-$Costs

Why do CA, CEA or CBA?

- Resources are limited
- Impact is necessary but not **sufficient**
  - **Cost** to replicate an **impact**

Example: Mentoring Program vs. After-school Program

Example: Cost Analysis

- Add-on high school mentoring program for 500 students:
  - 4 teachers: $100,000 each
  - 4 classrooms: $25,000 each
- Add-on after-school program for 1,000 students:
  - 6 counselors: $80,000 each
  - 1 gym: $120,000 each

	Mentoring Program	After-school Program
Total Number of Students	500	1,000
Personnel	$400,000	$480,000
Facilities	$100,000	$120,000
Total Cost	$500,000	$600,000
Average Cost	$1,000	$600

Example: Cost-Effectiveness Analysis

- Baseline:
  - School size: 500 students
  - Dropout rate: 20%
- Mentoring program:
  - Costs: $1,000 per student
  - Effectiveness: reduces dropout rate by 5%
- After-school program:
  - Costs: $600 per student
  - Effectiveness: reduces dropout rate by 2%

	Mentoring Program	After-school Program
Total Cost	$500,000	$300,000
Baseline Dropouts	100	100
Yield of New HS graduates	5	2
CE ratio	$100,000	$150,000

Example: Cost-Benefit Analysis

- Economic benefits of a new high school graduate compared to a dropout over lifetime:
  - Earns $120,000 more
  - Saves taxpayer $300,000 in spending on crime

	Mentoring Program
Total Cost	$500,000
Yield of New HS graduate	5
Total earnings gain	$600,000
Total crime saving	$150,000
Total Benefits	$750,000
Net Benefits	$250,000
BC ratio	1.50

Research Questions: Match to Method

- Which preschool model best prepares children for kindergarten for the cost?
- What is the cost of Supplemental Reading Program?
- Should we invest in High School Dropout Prevention Program?
- Which program is most efficient at increasing postsecondary enrollment?
- What portion of the cost of College Counseling Intervention is borne by the students?
- What resources are needed to replicate Early Intervention in Math?

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The Ingredients

Method

Key Concept

- Opportunity Cost: any ingredient (resource) used has a cost to someone or to society in the value of its best alternative use

- If a resources has a value or an alternative use, the opportunity cost should be considered because those resources may be important for replication

- Example: volunteers

Examples of Ingredients

- Obvious ingredients: books, additional staff, purchase of new curricula

- Not-so-obvious ingredients: volunteers, existing resources provided by schools (classrooms, computers, teacher time, principal time), teacher prep time, parent time

Costs ≠ Budgets

Costs and Budgets

- Budgets do not capture all the resources that go into implementation:
  - In-kind contributions
  - Purchases in other years
  - Resources obtained from other entities or reallocations from other activities

Costs and Proposal Budgets

- A cost analysis is a systematic investigation and analysis of the ingredients utilized in implementing the intervention

- The budget for the proposal or the amount needed to purchase the intervention listed in the proposal is not the cost analysis

Steps of the Ingredients Method

1. Identify ingredients required to obtain a given result

2. Value the ingredients using market prices or equivalent

3. Calculate the overall cost and average cost per participant

4. Determine who pays costs

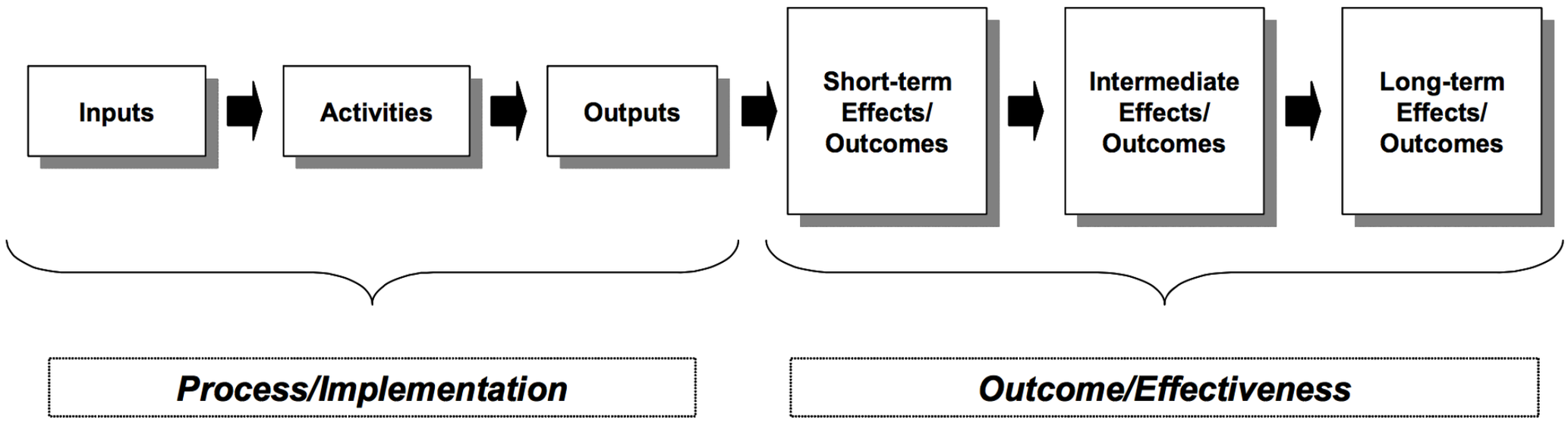
5. Relate costs to effectiveness (or benefits)

Step 1: Identifying Ingredients

- Theory of Change
- Program documentation
- Prior evaluation or implementation studies
- Own data collection: observations, surveys, time logs

Source: http://www.cdc.gov/getsmart/program-planner/Step3.pdf

Exhibit 3.1
Evaluation Domains — Boxes



Categories of Ingredients

- Personnel
- Facilities
- Material & Equipment
- Other
- *Training

Describing Ingredients

- Quality
  - Important for replication
  - Important to match ingredients to prices
- Quantity
- Important to distinguish between quality and quantity for sensitivity testing
- Example: volunteers

Information Needed to Estimate Costs

- Personnel
  - Full-time or part-time, calendar or academic year
  - Benefits, Qualifications, Education, Experience, Responsibilities
  - Volunteers
  - Training
- Facilities
  - Devoted or flexible
  - Overhead
- Material & Equipment
  - Computers, curriculum materials, books, desks, etc.
- Other
  - Transportation
  - Food, prizes, etc.

Data Collection

- Interviews:
  - Develop understand of the components of the program to inform the interview
  - Focus on high cost ingredients - personnel usually around 80% of total costs in education
- Observations:
  - Context
  - Identify missing ingredients
- Surveys
  - Teacher qualifications and training
  - Class size
- Time Logs:
  - Time allocation

Common Questions: Teachers

- Consider the role of teachers
- If role is support: quantity of time (hours per week)
- If role is main input for program: variation is important:
  - Level of education
  - Years of experience (overall and grade/subject-specific)
  - Special training

Common Questions: Materials/Facilities

- Shared or devoted to program
- If shared: what proportion is for this program?
- What's the life of the resource? When would it need to be replaced?

What are some examples from your experience where characteristics of resources might matter in the production of impacts?

Example: Sphero

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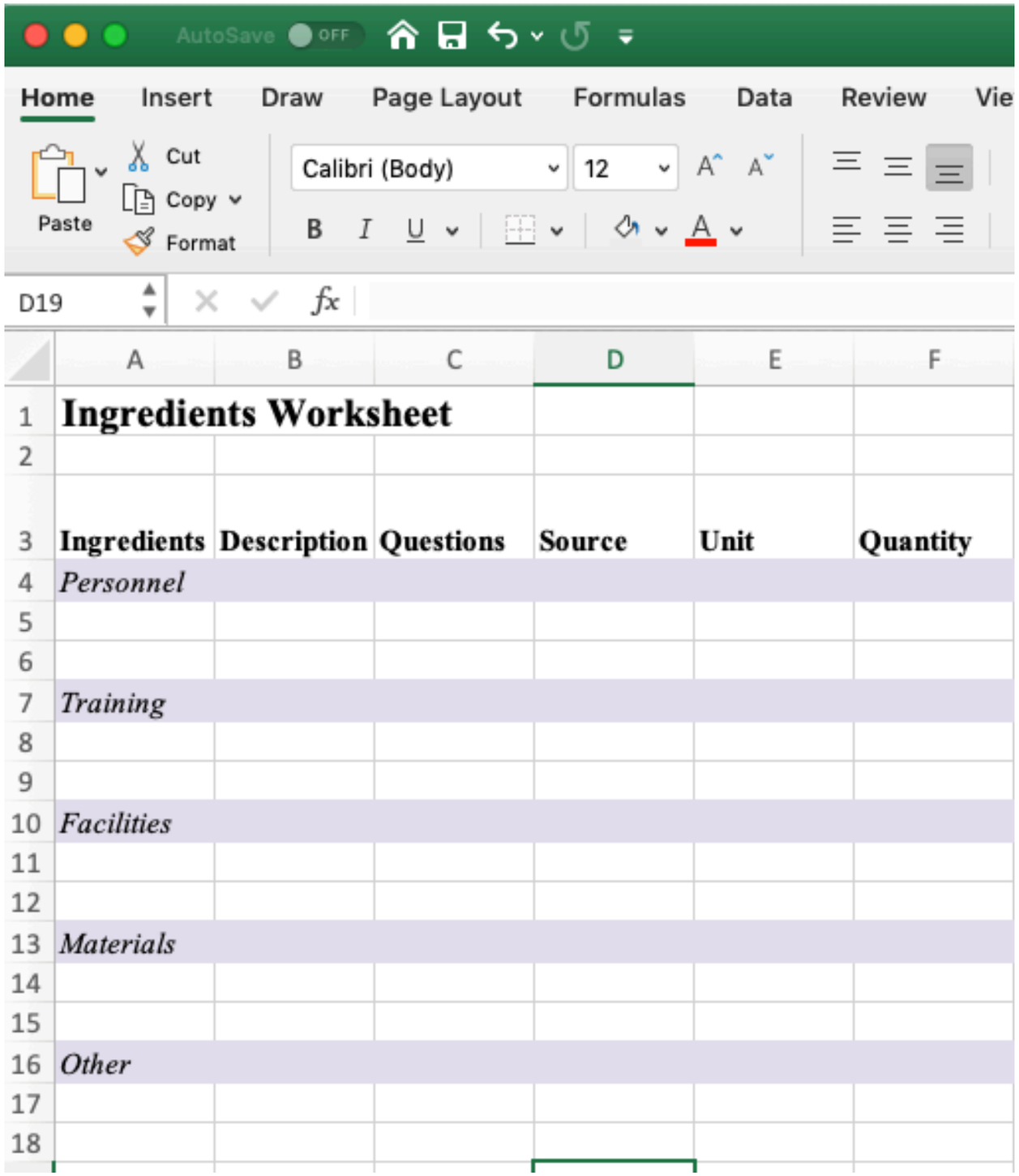

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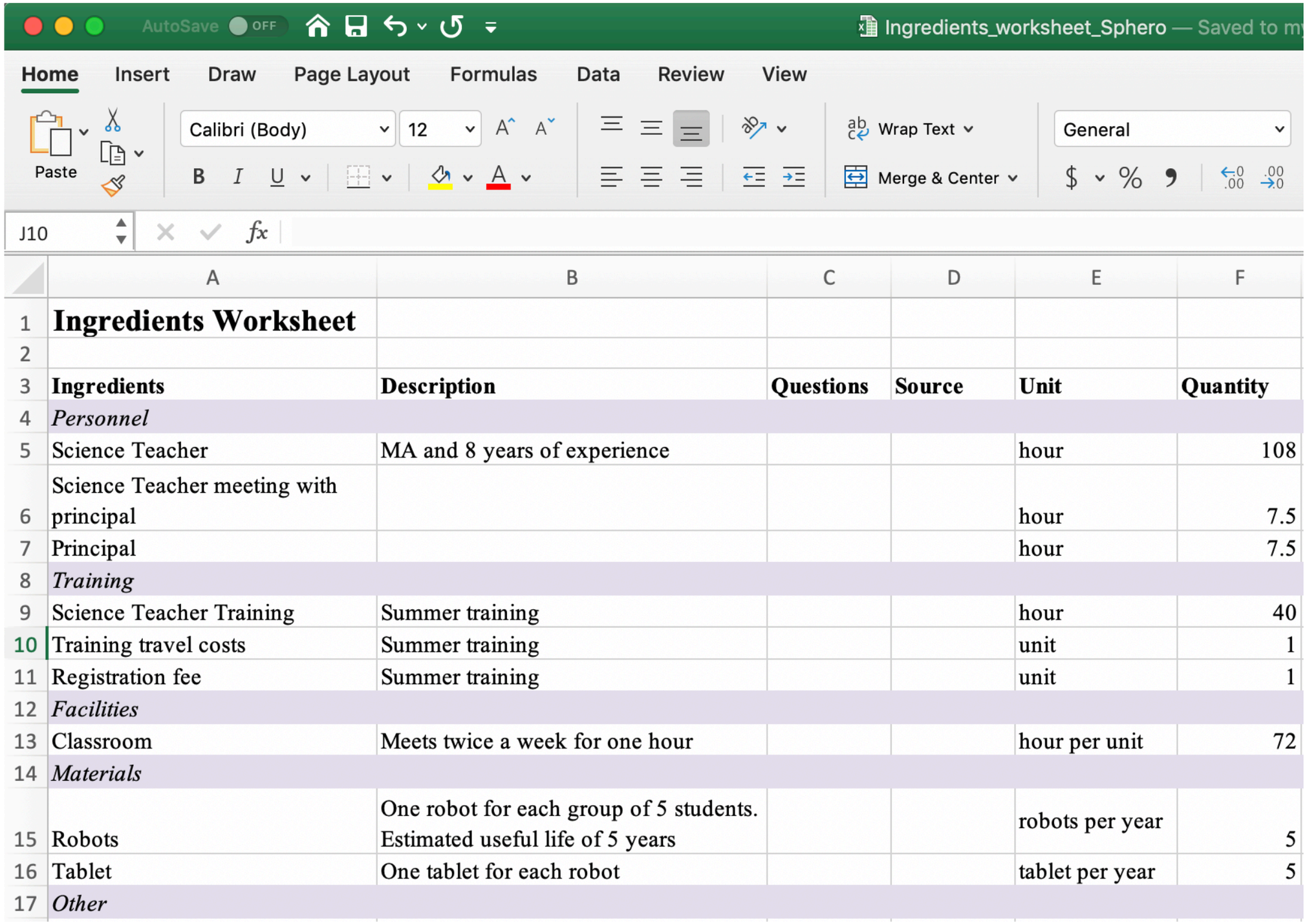

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2						
3	**Ingredients**	**Description**	**Questions**	**Source**	**Unit**	**Quantity**
4	*Personnel*					
5	Science Teacher	MA and 8 years of experience			hour	108
6	Science Teacher meeting with principal				hour	7.5
7	Principal				hour	7.5
8	*Training*					
9	Science Teacher Training	Summer training			hour	40
10	Training travel costs	Summer training			unit	1
11	Registration fee	Summer training			unit	1
12	*Facilities*					
13	Classroom	Meets twice a week for one hour			hour per unit	72
14	*Materials*					
15	Robots	One robot for each group of 5 students. Estimated useful life of 5 years			robots per year	5
16	Tablet	One tablet for each robot			tablet per year	5
17	*Other*					

Ingredients in an Evaluation

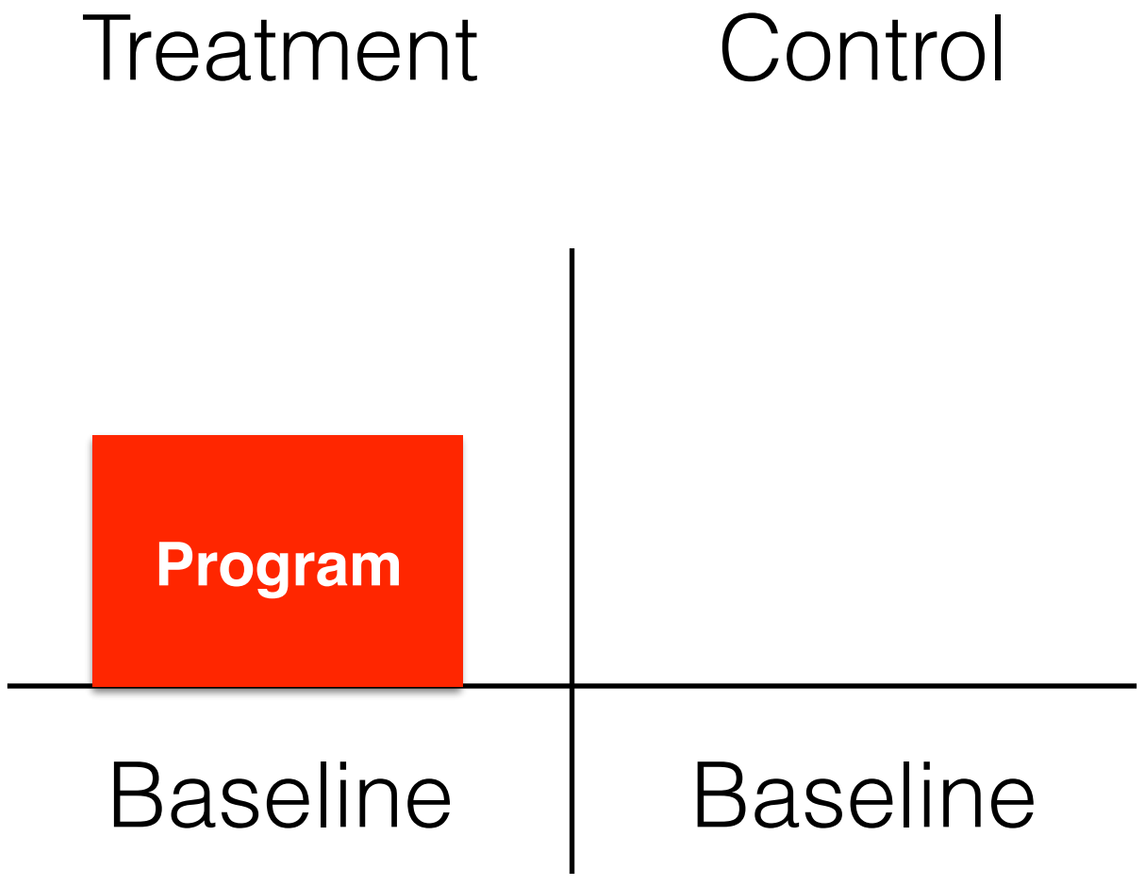
- Measure ingredients from treatment
- Measure ingredients from control
- Report both for transparency and policy context
- Take different to correspond to effectiveness estimates

Types of Programs Evaluated

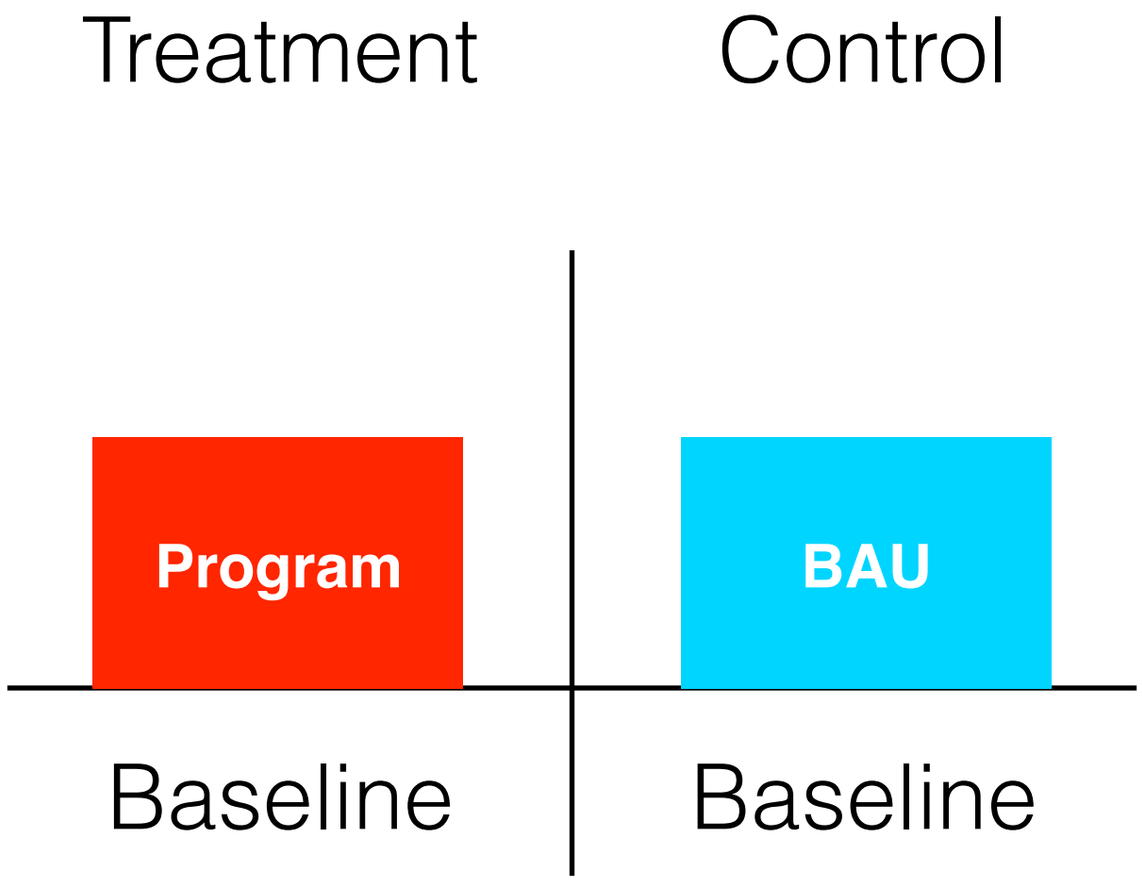
- **New**: intervention is unlike anything else being received and is in contrast to no service

- **Supplemental**: intervention is added onto existing programming or provides supplemental support in addition to standard practice

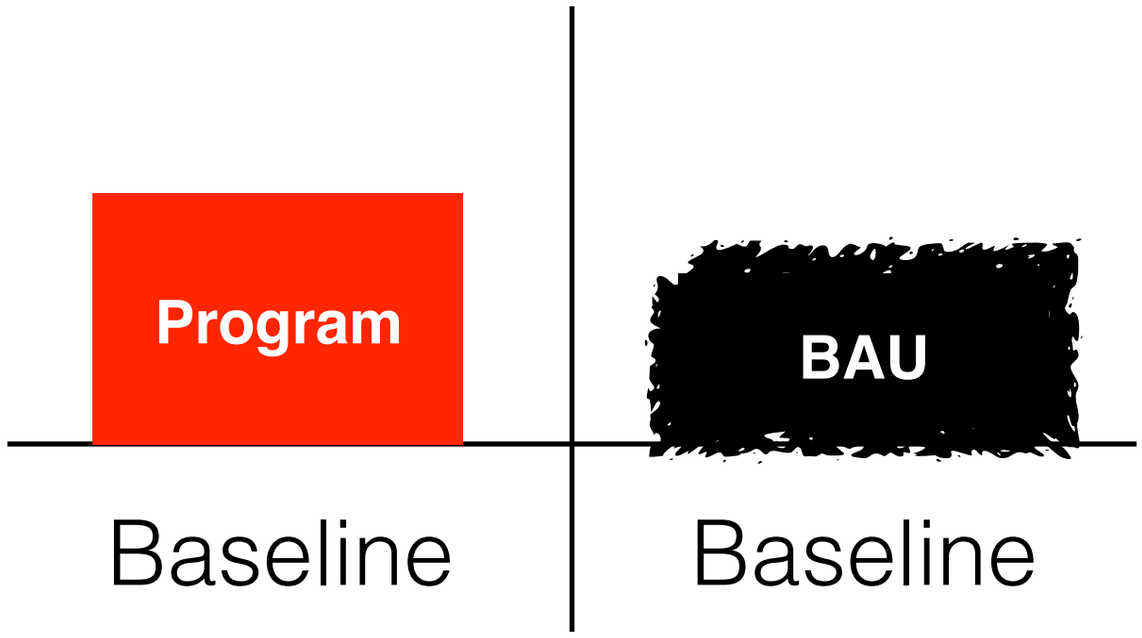
- **Replacement**: intervention is intended to replace standard practice



Here, the contrast between treatment and control is clear. The treatment, and associated costs, is incremental to business as usual. The program is an add-on being compared to doing nothing.



Here, the treatment, and associated costs, is an alternative to business as usual. The program replaces current practice.



Here, the contrast between treatment and control is not clear. The treatment may replace some of the practices of BAU but the treatment may also provide more service (resource) than would have been received otherwise.

Cost to replicate an

impact

Step 2: Pricing Ingredients

- Value we give to ingredients
- Standardized prices:
  - National
  - Local
- Data sources:
  - Multiple
  - CBCSE CostOut Toolkit

Pricing Issues

- No market for particular ingredients
  - Rental rates for educational facilities
- Market distortions - markets are not competitive
  - Price might reflect firm mark-ups rather than actual value of the resource
- No estimate for a national average price
  - Some ingredients are highly program-specific – need that curriculum, that training, etc. Useful for replication, but not a national average price
  - Travel – “typical” airfare? “Typical” hotel room?
  - Administrative overhead? IT services?

“Tricky” Ingredients

- Volunteer time
  - Value at minimum wage, market value of services provided, or actual wage of the person providing services
  - What if Bill Gates volunteered at a reading tutoring program?
- Client inputs
  - How to value parental time
  - Should we include student time? What is their opportunity cost? What is incremental?
- Training
- Facilities
  - Special spaces (e.g., science lab, gymnasium, auditorium)
  - Flexible space
  - Accounting for land acquisition, furnishings, utilities, maintenance

Inflation

- Inflation refers to an increase in general level of prices over time

- Nominal prices from different time periods need to be adjusted using price indices to measure prices in consistent units of value

- Example using Consumer Price Index (CPI) from Bureau of Labor Statistics:

$$\frac{P_2}{P_1} = \frac{CPI_2}{CPI_1} \qquad P_2 = \frac{P_1 \times CPI_2}{CPI_1}$$

Amortization

- Capital is often financed through borrowing
- Typical approach is to amortize capital over useful life of the project
- This is akin to charging the year-by-year “use” of the infrastructure (and interest costs on unused part to account for opportunity cost) as the annual cost
- Most frequently used for facilities, but also durable equipment, supplies, human capital (e.g., training)
- Depreciation/Amortization can be calculated using this formula, or an amortization table:

$$A = P\,\frac{r(1+r)^n}{(1+r)^n - 1}$$

Present Value Discounting

- Costs occur at different times, especially in a multi-year program
- Dollars now are worth more than dollars later: why?
  - Time preference
  - This is a separate issue from inflation
- Discrete case:

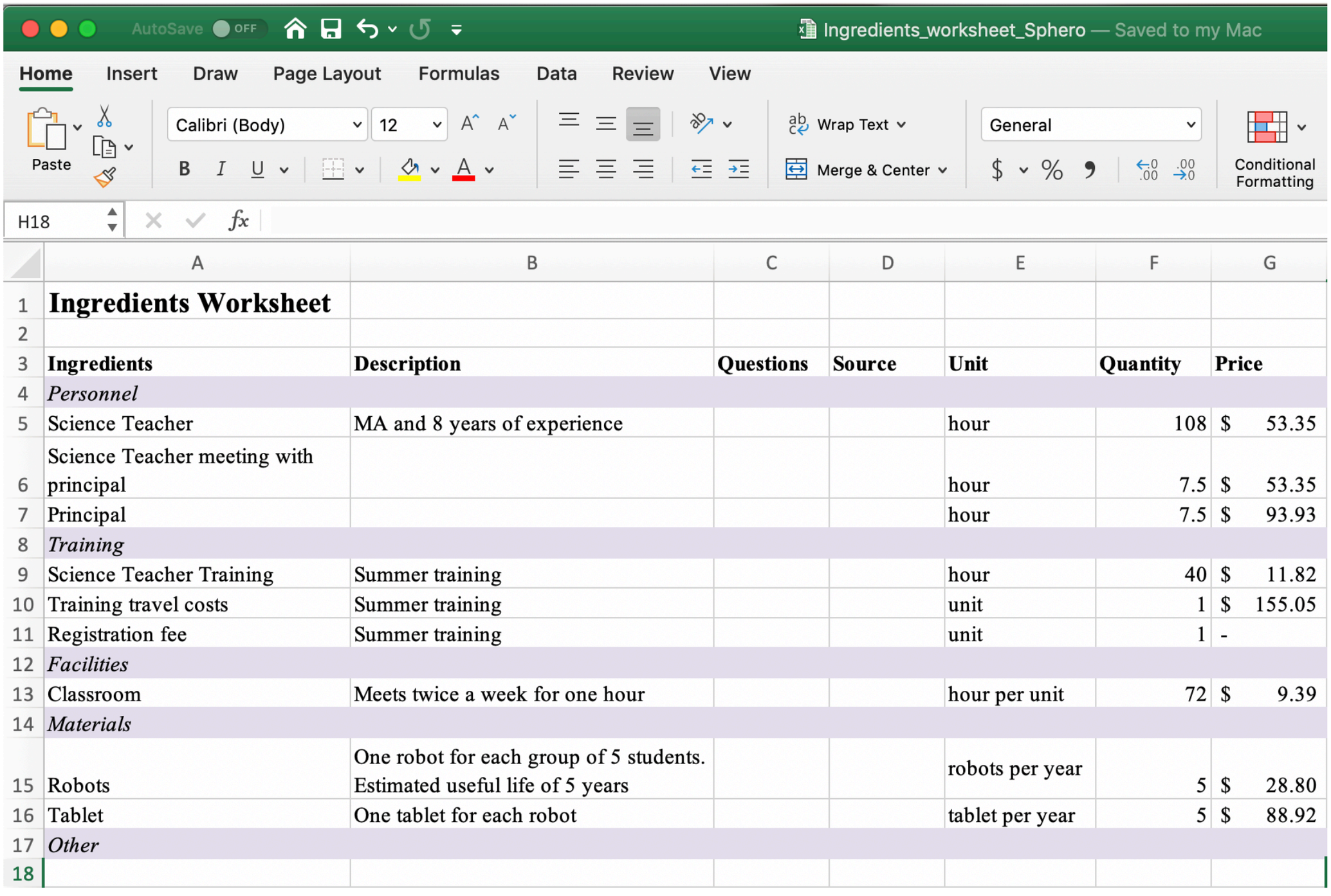
$$PV = \frac{C}{(1+r)^{t-1}}$$

- Corresponding continuous formula:

$$PV = C \times e^{r(1-t)}$$

Adjustments	Rationale	Decisions to make for the project	Information to input for an ingredient
Inflation	Rescale nominal prices in different years using consistent units of value	In which year do you want to express costs	Year of price
Present value	$1 received in the future is worth less than $1 now	Discount rate	Year in which quantity is used
Geographical location	The purchasing power of $1 differs in different locations	In which geographical location do you want to express costs	Geographical location of a price item
Wage converter	Align the unit of a price with the unit of the ingredient	NA (ingredient-level decision)	Which unit do you want to convert the price to
Amortization	Carve out the part of resources that contribute to the program	NA (ingredient-level decision)	1) Number of years that the cost is spread over 2) Discount rate
Fringe benefits	Fully capture the market price of the personnel	NA (ingredient-level decision)	Fringe benefit rate as a percentage of salary/wage

Example: Sphero



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7	Principal				hour	7.5	$ 93.93
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9	Science Teacher Training	Summer training			hour	40	$ 11.82
10	Training travel costs	Summer training			unit	1	$ 155.05
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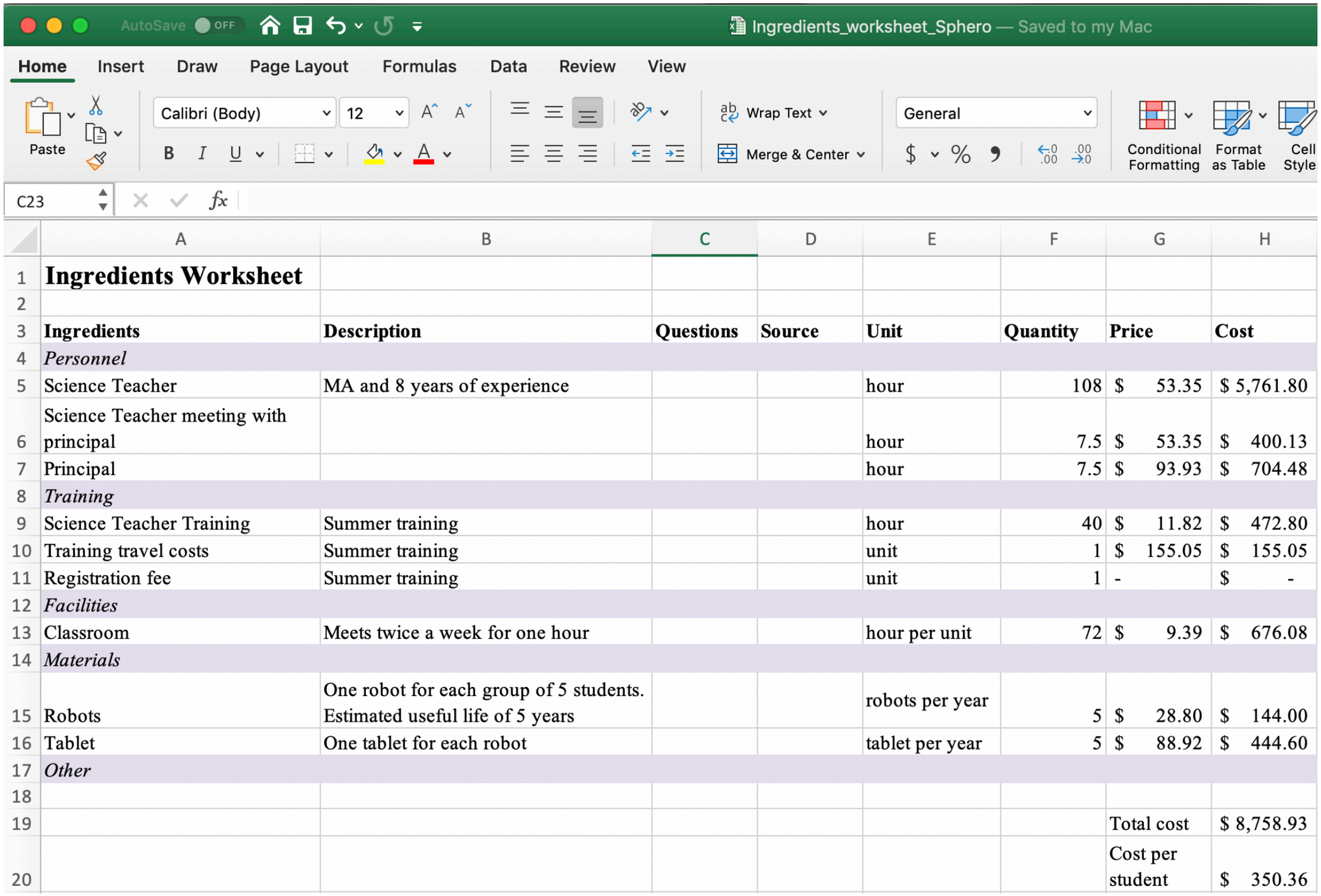
12	*Facilities*						
13	Classroom	Meets twice a week for one hour			hour per unit	72	$ 9.39
14	*Materials*						
15	Robots	One robot for each group of 5 students. Estimated useful life of 5 years			robots per year	5	$ 28.80
16	Tablet	One tablet for each robot			tablet per year	5	$ 88.92
17	*Other*						
18							

Step 3: Estimate Costs

1. Ingredient Cost=Quantity*Price
2. Total Cost= Sum all ingredient costs
3. Average cost per student = $TotalCost/students
4. Subtract control cost from treatment cost

Example: Sphero



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16	Tablet	One tablet for each robot			tablet per year	5	$ 88.92	$ 444.60
17	*Other*							
18								
19							Total cost	$ 8,758.93
20							Cost per student	$ 350.36

Step 4: Distribution of Costs

- Who paid for the ingredients?

- Usually we think of costs borne by the school, volunteers, the program.

Step 5: CEA or CBA

- Costs and effects (benefits) must reflect the same delivery, population, location, time
- Important to consider:
  - Sampling
  - ITT/TOT
  - Variation
  - Context of other policy alternatives

Example: Sphero

1. CE ratio: $189.85/0.1=$1,898

2. Alternative program CE ratio: $440/0.2=$2,200

Designing a Cost Study

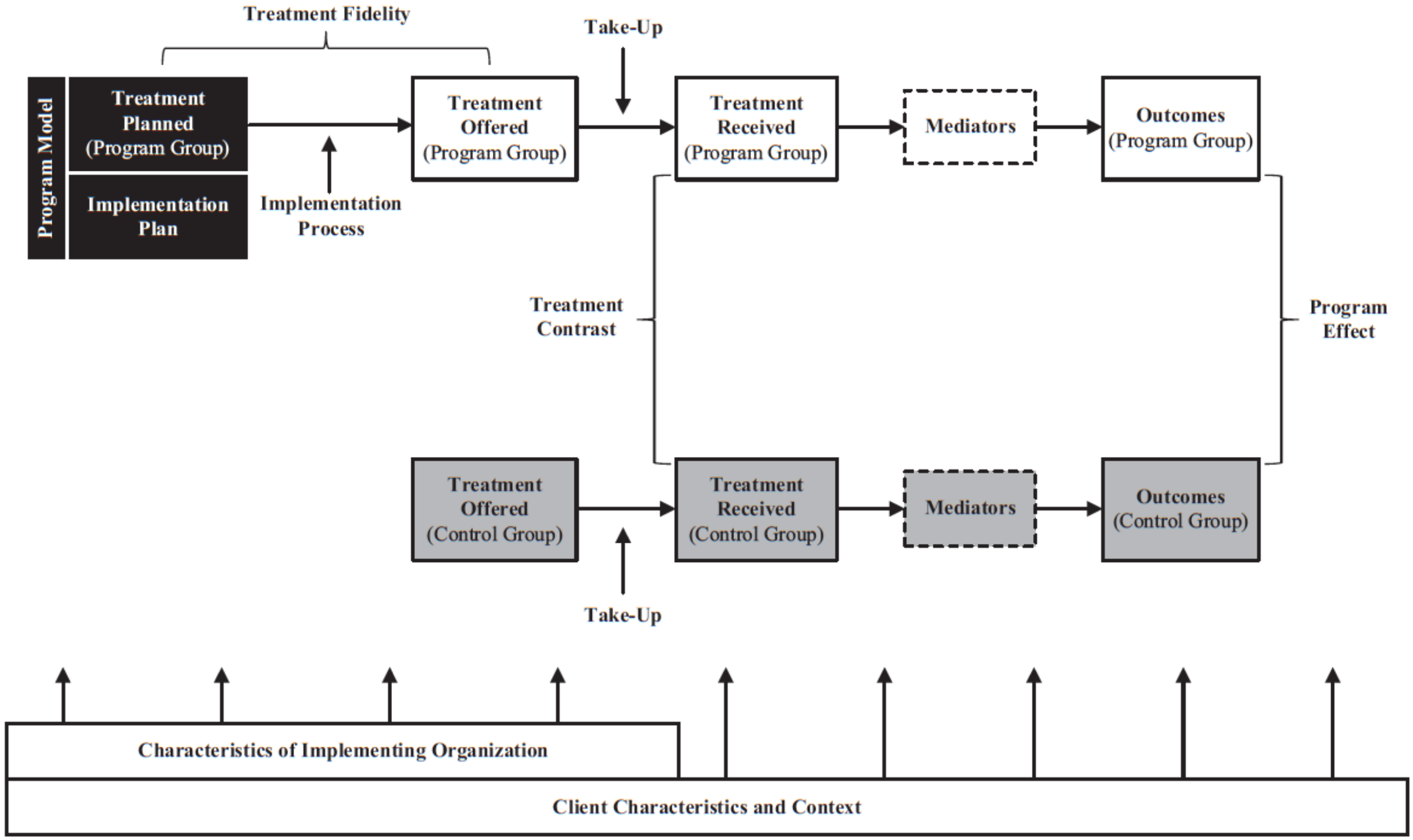

Figure 1. A Conceptual Framework for Studying Variation in Program Effects, Treatment Contrasts, and Implementation.

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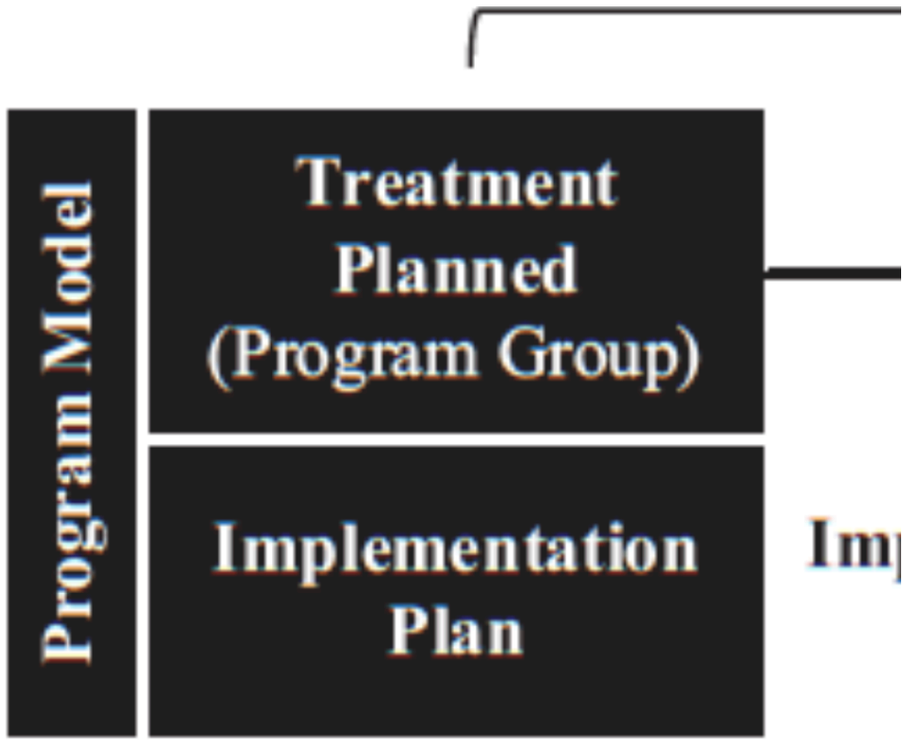
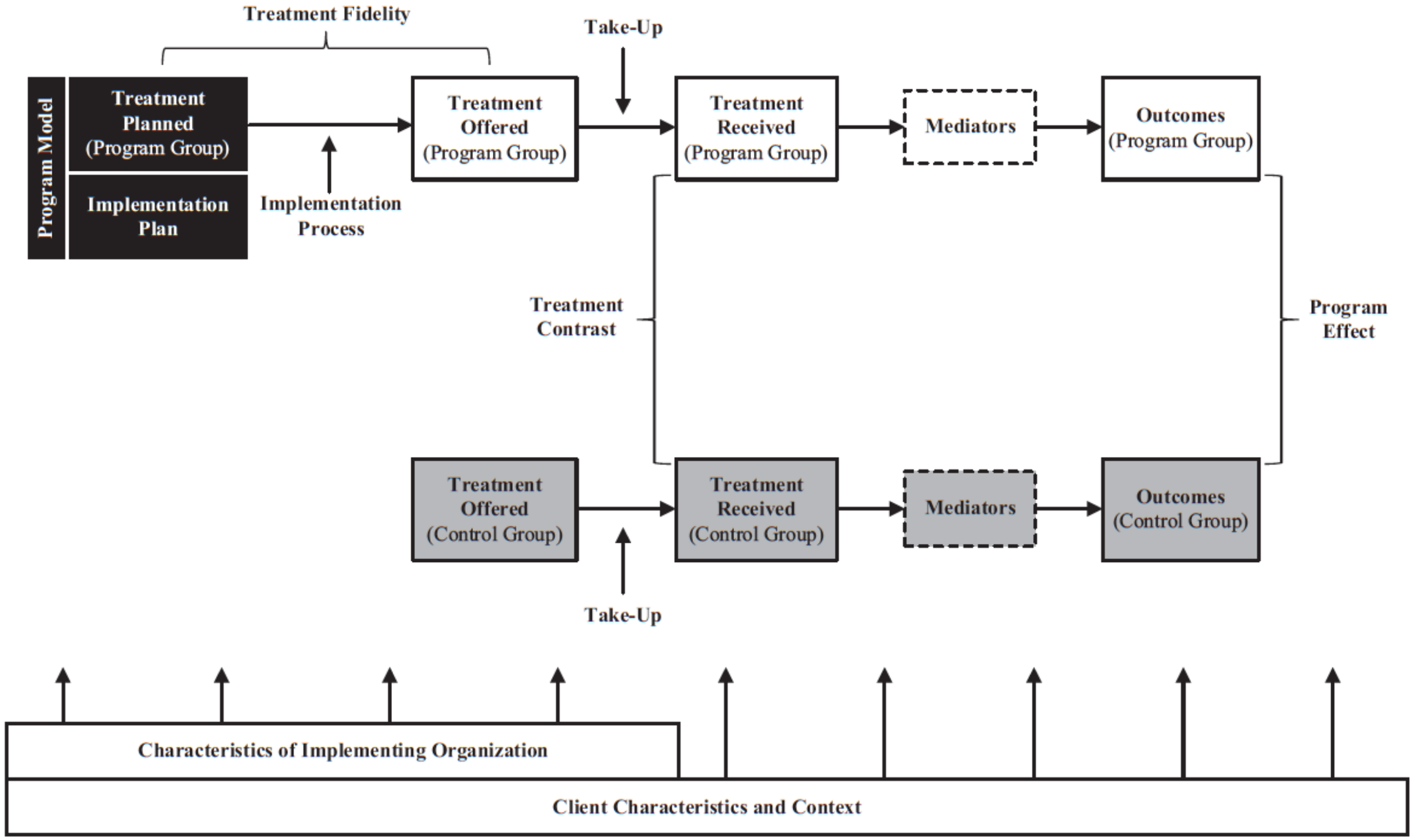


Resources can be identified at this point based on program as designed and planned for the evaluation

This is an important starting point in designing research on costs. By understanding the program as planned and the program's theory of change, the research on costs can be designed and outlined at the proposal stage. This helps to ensure that the cost component is part of the larger story.



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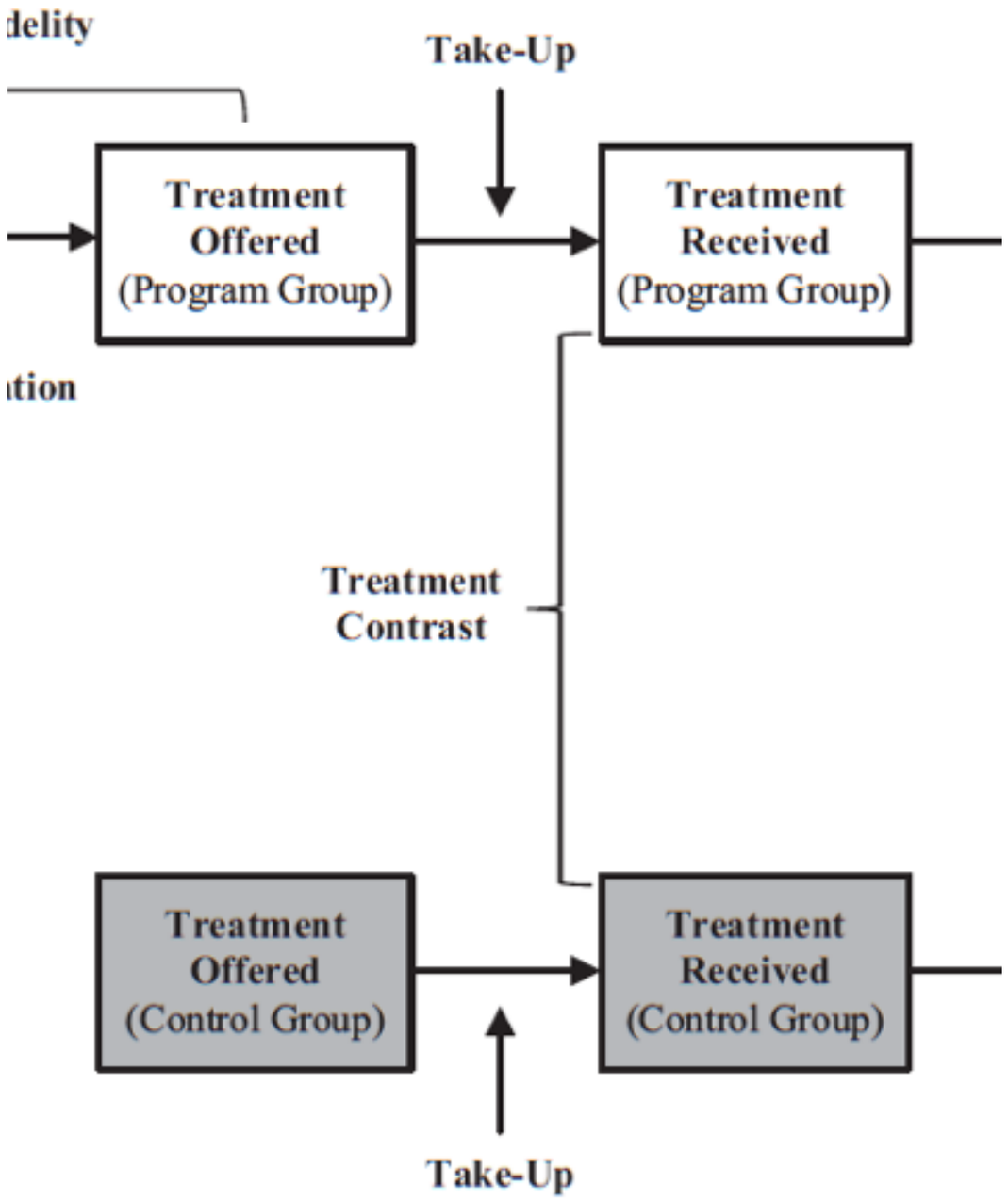


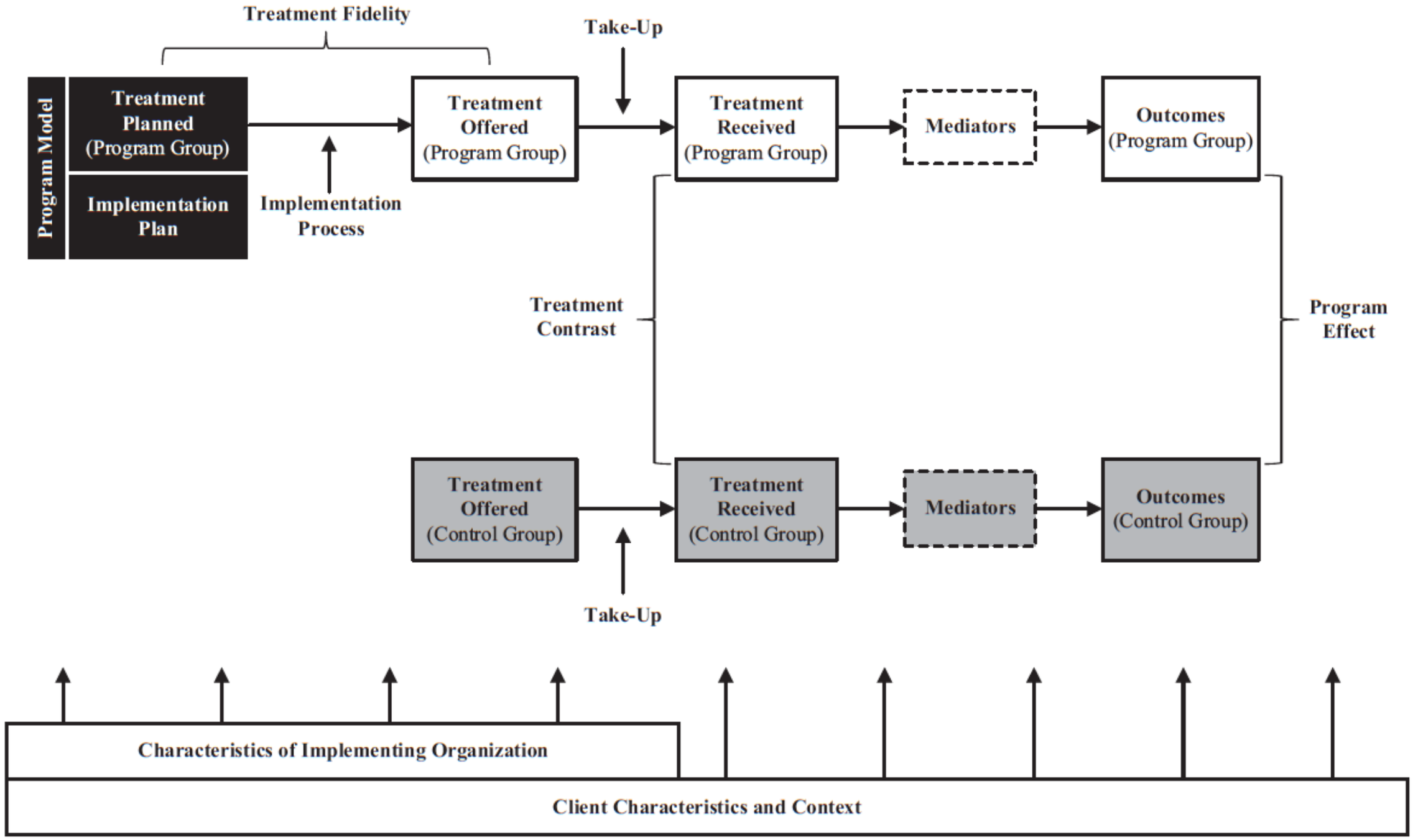
Resources are delivered during this time and should be observed/ measured to reflect implementation and treatment contrast

Treatment contrast is critical for estimating impacts. The contrast in resources (treatment - control) reflects the production of these impacts. In many cases, we need to know the resources for treatment, control, and the contrast.

Other

Induced Costs

- Measure any change in service receipt induced by the intervention
- Direct program costs + indirect induced costs
- Careful attention to treatment contrast
- Examples:
  - Helping students complete FAFSA induces new students to attend college
  - Summer counseling induces less “melting” in Fall and higher college enrollment



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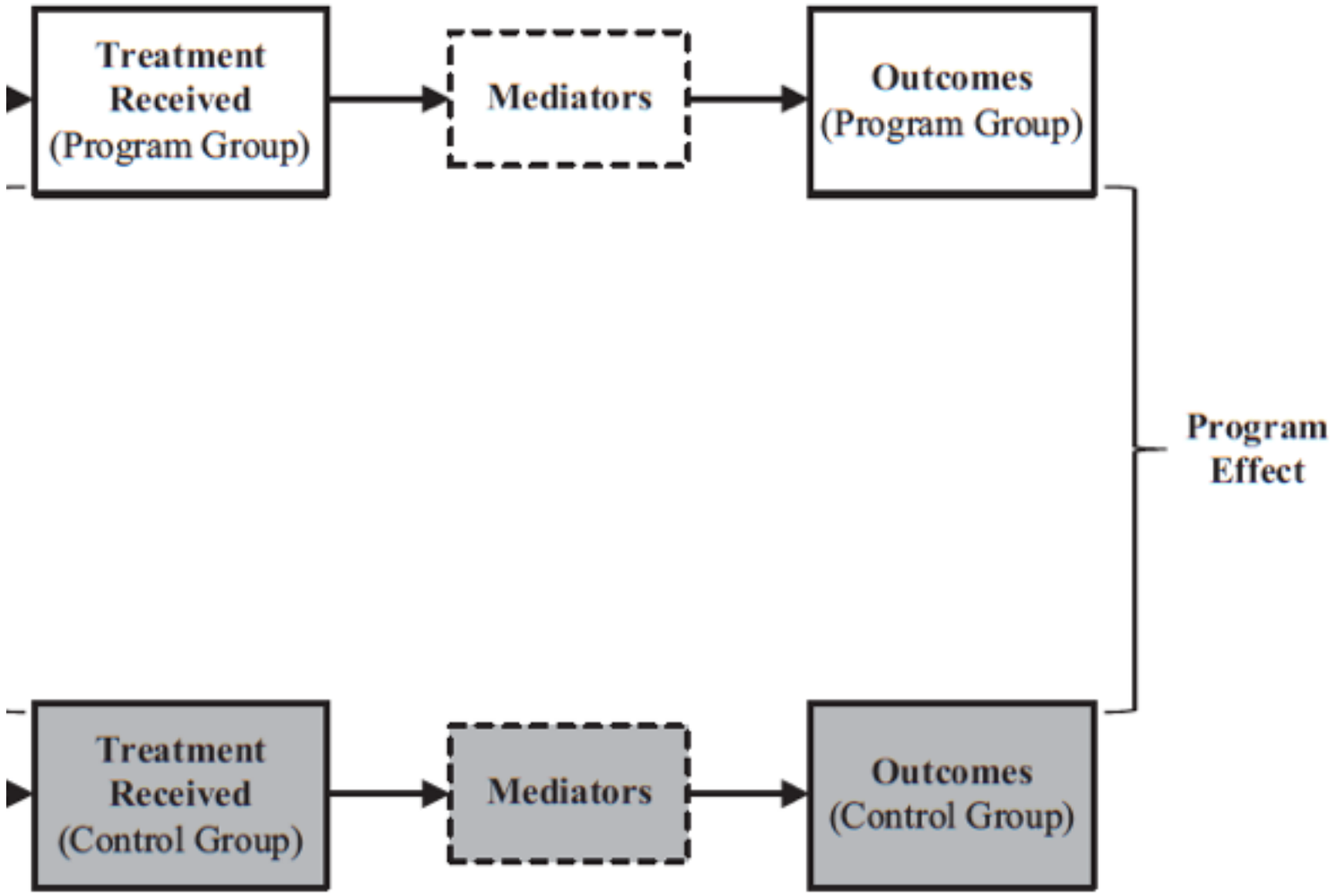

Careful not to overlook mediators.

Many treatments in education induce a change in services received by students that mediate the outcome ("service mediation interventions). This is a critical component of treatment contrast and the production of effects.

See: Bowden, A.B., Shand, R., Belfield, C.R., Wang, A., & Levin, H.M. (2017). Evaluating Educational Interventions that Induce Service Receipt: A Case Study Application of City Connects. American Journal of Evaluation, 38(3), 405-419.

Sensitivity Analysis

- Essential to test the importance of your assumptions
- Partial Sensitivity Analysis
  - Vary one important assumption and hold all else equal
- Extreme case Analysis
  - Vary assumption to get the best/worst outcomes
- Other techniques for BCA
  - Breakeven Analysis
  - Monte Carlo Simulations

Additional Resources

3 edition

Henry M. Levin
Patrick J. McEwan
Clive Belfield
A. Brooks Bowden
Robert Shand

ECONOMIC EVALUATION in EDUCATION

Cost-Effectiveness and Benefit-Cost Analysis

Resource: CostOut

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Publications

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Topics include: cost-effectiveness, benefit-cost, comprehensive student support, early childhood, education technology, high school completion, literacy, school reform, social and emotional learning, returns to education, high school dropouts, increasing college graduation, teacher certification and selection, and health-related interventions.

You can also filter the publications library by one of the two categories below.

METHODOLOGY & GUIDANCE

PRACTICAL APPLICATIONS

Partnerships: Minnesota Reading Corps

MINNESOTA READING CORPS PROGRAM

Minnesota Reading Corps PreK Program

The program

- A statewide AmeriCorps early literacy initiative that aims to foster emergent reading skills of children to ensure reading proficiency by the end of grade 3
    - Brings AmeriCorps members into Pre-K classrooms
    - Provides literacy enrichment for the whole class
    - Provides tutoring services for specific at-risk students
    - Currently implemented at over 300+ Pre-K sites across Minnesota

Key components

- An add-on classroom instructional capacity through a full-time or part-time tutors (AmeriCorps members)
- A dedicated coaching and a supervisory support structure that enhances instructional skills of AmeriCorps members
- An interactive and skills-focused literacy instructional model called “SEEDS of Emergent Literacy”

Evaluating *Minnesota Reading Corps PreK Program*

Previous evaluations on effect

- Outcome evaluation (NORC, 2014) found significant positive effects on outcomes of emergent literacy for 3, 4 and 5 year olds

Our cost study of *Minnesota Reading Corps*

- Costs of replicating the MRC Pre-K program that produced the impacts on students' reading skills measured by the 2013-2014 NORC outcome assessment
  - Average costs per site and per student
  - Variation in costs across sites
  - Distribution of costs between schools and program

Some highlights about what we did

- Minnesota Reading Corps collected rich administrative data → able to specify the quantity of each ingredient for *each of the 25 sites*
- Missing information were simulated so as to enable estimation of site-level cost
- Valued each ingredient based on national price with a few exceptions

Total Costs of Minnesota Reading Corps

Estimate Type	Cost
Total Cost for 24 Sites	$1,515,970
Weighted Average Cost Per Student	$1,210
Variation at the Site Level	
Average Cost Per Student	$1,400
	($560)

Note: Dollars reported in 2014 US $ and rounded to the nearest ten. Standard errors of student-level statistics are in parenthesis.

Distribution by Ingredient Category

	Personnel	Facilities	Materials & Equipment	Training	Other
Weighted Average Cost Per Student	$1,000	$20	$40	$150	$30
	($480)	($10)	($10)	($80)	($10)
Percent	81%	2%	3%	12%	2%

Note: Dollars reported in 2014 US $ and rounded to the nearest ten. Costs shown are weighted averages of student-level costs. Standard errors of student-level statistics are in parenthesis.

Distribution by Perspective

	School	Program	Members	Families
Personnel	$210	$670	-	$140
	($100)	($400)	-	-
Facilities	$20	$10	-	-
	($10)	($10)	-	-
Materials and Equipment	$30	$20	-	-
	($10)	($10)	-	-
Training	$80	$50	$20	-
	($50)	($30)	($30)	-
Other	-	$30	-	-
	-	($20)	-	-
Total	$320	$750	$20	$140
	($140)	($420)	($30)	-
Percent	26%	61%	2%	11%

Note: Dollars reported in 2014 US $ and rounded to the nearest ten. Costs shown are weighted averages of student-level costs. Standard errors of student-level statistics are in parenthesis.

BU Projects!

Step 0: Identify the Appropriate Method

- Cost Analysis
- Cost-Effectiveness Analysis
  - What is your effectiveness measure?
- Cost-Benefit Analysis
  - How will you monetize benefits?

Step 1: Identify Ingredients

- Think about the Theory of Change and the resources that go into it.
- What documentation can you rely on to obtain this information?
- What do you need to collect on your own? What types of data would you collect?
- Can you integrate data collection efforts to implementation or fidelity analyses?
- What is your control group? What resources are they getting?
- What type of program is your program? New, supplemental or replacement? Will you estimate costs for both control and treatment? Can you recover incremental costs?

Step 2: Pricing Ingredients

- Will you use national or local prices?

- What ingredients you think will be tricky to price out?

Step 3: Estimate Costs

1. Will you estimate average cost per student?
2. Will you estimate average cost per site?
3. Will you estimate average cost per teacher?
4. What is the relevant estimate that will contribute to the story of your research?

Step 4: Distribution of Costs

- Identify the important contributors to the cost of your interventions.

- Do you expect variation across sites? How will this variation relate to your impacts?

Step 5: CEA or CBA

- Think about:
  - Sampling
  - ITT/TOT
  - Context of other policy alternatives

Thank you!

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