

Developing Multi-Variable Thinkers

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How do we develop multivariable thinkers?

There is now widespread enthusiasm for the idea that today's students need to acquire "21st century skills." Teaching old knowledge isn't enough. To thrive in today's world, young people need to analyze and apply new information to new problems. Our young people need to progress from univariable to multivariable mental models of causality.

Even young children can isolate causes in very simple belief-neutral contexts, and the development of controlled comparison has been studied extensively. Controlled comparison develops with rich engagement, whether or not direct instruction is included (Dean & Kuhn, 2007). A greater challenge is developing the ability to reason about multiple causes working together. We describe 2 studies targeting multivariable reasoning. A second component examines whether students develop the ability to recognize the need to make comparisons between groups.

What Did We Do?

Study	Details
Study 1	<ul style="list-style-type: none"> Intervention students participated for 3 years in 6th-8th grades. The intervention took place over 20-24 sessions each year in 3 classrooms from a University-affiliated magnet urban public school in New York City. Students used computers to investigate data, with the goal of finding causal relationships. The software provided scaffolding: scaffolding was reduced each year. Students investigated databases case by case in 6th grade and half of 7th grade. For the second half of 7th grade and all of 8th grade, students used the software Inspiro Data to investigate larger trends. See below for a screen shot. The control group was from a private, independent school for college-bound students who received their usual social studies curriculum.
Study 2	<ul style="list-style-type: none"> This intervention lasted 10 sessions during a single unit embedded within the science curriculum in 7th grade. The intervention took place at the same school as in Study 1. Three classrooms were randomly assigned a condition, with two classrooms participating in the experimental intervention and one classroom as the control group. The experimental condition received our intervention and the control group had "business as usual." The intervention students used InspiroData to investigate a database on Body Mass Index (BMI) and variables that may affect an individual's BMI. Students collected the data they investigated. Control and intervention groups were both taught by the same classroom teacher; a research assistant helped with the experimental classrooms.



Screenshot from Inspiro Data.

After the intervention, What Did THEY THINK?

Posttest Prompt: The Cancer Task

The Public Health department of Portland, Ohio has noticed that the percentage of residents diagnosed with cancer is much higher in the inner city than in the outlying neighborhoods. The department is undertaking a study to find out why. You have been assigned the job. Describe the study you would do.

Coding

- First, did they design a study involving more than one variable or just a single variable? And if they studied more than one variable, did they consider additional variables to be alternatives to each other (but still search for a single causal variable) or did they acknowledge that multiple variables could have an additive effect. This dimension was coded as Single, Alternative, or Additive.
- Second, did they design a study with two-group comparisons, or did they consider it enough to gather data from only one population. This dimension was coded as presence of two-group comparison or lack of two-group comparison.

Examples of Posttest Responses

Dimension 1: Multiple variables vs Single variables

Single Variable

"I think the well from which water is collected in town contains harmful materials that could give one cancer. I would compare their water to clean bottled water and also run tests to see what is in the water. If there were harmful materials in the water, the water is unsafe and should be replaced."

"I would compare the inner city and outlying neighborhood to see if there was a difference in the pollution levels."

ALTERNATIVE Variables

"There are many things that could cause this. I would create a survey that asks all of them in both neighborhoods. Then I would see which one made it more or less likely to have cancer."

ADDITIVE Variables

"I would check the variables that can affect cancer, so check for air pollution, water pollution, and which place smokes the most. I think I'll find that the place that smokes the most and the place that has the most air pollution will have the most cancer."

Dimension 2: Two-group Comparison

Two-group comparison

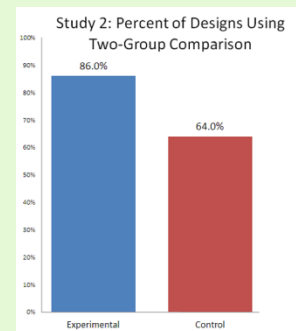
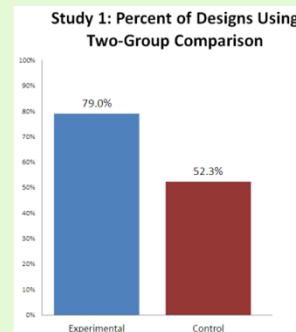
"In my investigation I would select a minimum of 20 (or more) inner cities and record the cancer rate and (student's underline) pollution [sic] level of all 20 inner cities. Then I would select 20 outlying neighborhoods and also record their pollution rate and their cancer rate." "How I will go about and start my investigation is that I will interview people from the inner city and outer neighborhoods."

No two-group comparison

"I would compare the water used by that [the inner city] community to clean bottled water." "I will survey at least 500 people in a specific inner city area on whether or not they have health insurance and I will also get scientists (more like pay them) to test the air quality in that area."

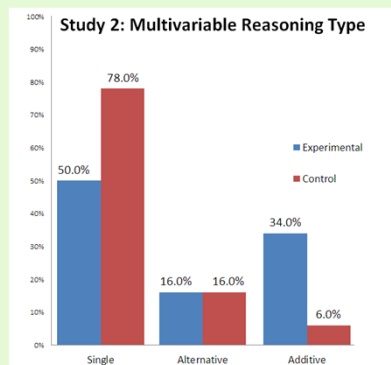
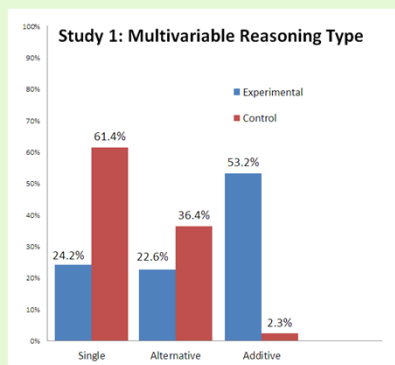
What Did We Find?

Use of two-group comparison



What Did We Find?

Use of multiple variables vs. single variables



What Do We Know?

Students receiving our intervention, whether over a three-year-period or during a single unit over two weeks, have all shown superior scientific reasoning over control groups. Not only were students in the intervention more likely to use multiple variables in their designs, but they also recognized the need for two-group comparison, an important factor in scientific reasoning.

Future work includes examining whether a second intervention will provide additional benefits as well as further exploring students' scientific reasoning as demonstrated in reports they produce during the intervention.

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